Does "Guangdong-Hong Kong-Macao Greater Bay Area" Promote OFDI Reverse Innovation Spillovers in Provinces Along the Line?

-- Empirical analysis based on difference-in-differences model

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Abstract. Based on the panel data of 30 provinces and cities with provincial status across the country from 2011 to 2016, this paper explores the impact of Initiative of Guangdong-Hong Kong-Macao Greater Bay Area on the development of OFDI reverse innovation spillovers in the provinces along the line. This paper empirically tests the impact of the Guangdong-Hong Kong-Macao Greater Bay Initiative on the development level of OFDI reverse innovation spillovers in the provinces along the line by using the difference-in-differences method. The study found that the Guangdong-Hong Kong-Macao Greater Bay Initiative has effectively improved the development level of OFDI reverse innovation spillovers in the provinces along the line in China. From the dynamic test results, it can be seen that the Guangdong-Hong Kong-Macao Greater Bay Initiative has had an impact on the development of OFDI reverse innovation spillovers in the provinces along the line since it was proposed, and the policy effect has gradually strengthened. The robustness of the regression results is further verified by eliminating the 11 provinces of the Yangtze River Economic Belt to eliminate the impact of exogenous events, which shows that the promotion of the policy of the Guangdong-Hong Kong-Macao Greater Bay Region on OFDI in the provinces along the line is not affected by the pre-policy factors, nor by other events. The conclusion of this paper has important implications for the optimization of regional industrial policies and the development of Guangdong, Hong Kong and Macao in the background of dual circulation.

Keywords: Difference-in-Differences Model; OFDI Reverse Innovation; Optimization of Regional Industrial Policies in Guangdong Hong Kong and Macao.

1. Introduction

It has become an indisputable fact that technological progress is the core driving force of long-term and stable economic growth. Sehumpeter (1934), Solow (1970), Grossman and Helpman (1994) and other economists have already proved that the reason why developed countries can achieve sustained economic growth is precisely due to technological innovation (Lin Yifu). General Secretary Xi Jinping once said: "China is the largest developing country in the world, and development is the key to solving all China's problems. To develop, we must give full play to the role of science and technology as the primary productive force."

After the implementation of the "go global" strategy, China has been more active in participating in economic globalization. China's outward direct investment (OFDI) has increased in consecutive years. At the end of 2020, China's OFDI reached US $153.71 billion, an increase of 12.3% year on year, ranking the first in flow scale in the world for the first time. The stock of China's OFDI is 2580.66 billion US dollars, an increase of 381.78 billion US dollars over the end of last year, 86.3 times of the stock at the end of 2002, and its share in the global OFDI stock has risen from 0.4% in 2002 to 6.6%, with the ranking rising from 25th to 3rd, second only to the United States and Netherlands. In terms of stock size, there is a large gap between China and the United States. Only 31.7% of the United States. By the end of 2020, China's 28000 domestic investors have set up 45000 foreign direct investment enterprises (hereinafter referred to as "overseas enterprises") outside the country, which are distributed in 189 countries (regions) around the world. At the end of the year, the total assets of overseas enterprises are 7.9 trillion US dollars.

In the context of China's continuous deepening of international trade cooperation, the relationship between science and technology and foreign trade has also attracted more and more attention from domestic economists. The reverse technology spillover effect means that OFDI's outflow is aimed at acquiring more advanced intellectual elements, technology, information and other resources of the host country to improve the technological competitiveness of enterprises in the home country and realize the diffusion of advanced technology from the host country to the home country [1]. There are four channels of international technology spillover: Inward foreign direct investment (IFDI), outward foreign direct investment (OFDI), export trade and import trade [2]. For China, China's OFDI has a significant reverse technology spillover effect. By conducting OFDI to leading countries in science and technology, we can obtain advanced technology more directly and promote China's technological progress [1]. In addition, many scholars have also confirmed that China's innovation capability has been significantly improved through the reverse technology spillover effect [3]. Therefore, the Chinese government has also issued a series of policies and taken a series of welfare measures to actively promote enterprises' foreign investment. For example, in 2018, the CCPIT launched the "20+20 Plan for Chinese Enterprises to Go Global", that is, to support enterprises' foreign investment in 20 key countries and 20 overseas key economic and trade cooperation zones through various ways.

Bay area economy refers to a coastal economic form that gathers a series of economic and social activities and realizes regional economic cooperation based on the bay or several connected harbors and islands. Wu Sikang believes that a high degree of openness and innovation leadership are the typical characteristics of the Bay Area economy [5]. The development of the Bay Area economy is the need to further promote the opening up to the outside world and the internal need to allocate resources in a larger scope and achieve better development [6]. In addition, the economy of the Bay Area also has an extraordinary function of agglomeration and spillover, and is an advanced economic form that drives the country's economic take-off and technological progress. In March 2015, the National Development and Reform Commission, the Ministry of Foreign Affairs and the Ministry of Commerce jointly issued the "*Vision and Action to Promote the Joint Construction of the Silk Road Economic Belt and the 21st Century Maritime Silk Road*", which officially put forward for the first time: "Deepen cooperation with Hong Kong, Macao and Taiwan, and build the Guangdong-Hong Kong-Macao Greater Bay Area." Subsequently, on July 1, 2017, under the witness of the General Secretary Xi Jinping, the Framework Agreement on *Deepening Cooperation Between Guangdong, Hong Kong and Macao to Develop the Greater Bay Area* was signed in Hong Kong, which accelerated the development and construction of the Guangdong-Hong Kong-Macao Greater Bay Area. On February 18, 2019, the State Council issued *the development plan for Guangdong-Hong Kong-Macao Greater Bay Area*, and issued a notice requiring all departments in all regions to conscientiously implement it in combination with the actual situation, and build the Guangdong-Hong Kong-Macao Greater Bay Area into an economy that is the benchmark of the three dozen Bay Areas in the world [4]. It can be seen that the development of the Greater Bay Area of Guangdong, Hong Kong and Macao is a key milestone in China's opening up process and has a far-reaching impact on China's foreign direct investment.

In short, the Greater Bay Area of Guangdong, Hong Kong and Macao has important strategic significance for promoting OFDI in China. The construction of the Guangdong-Hong Kong-Macao Greater Bay Area is conducive to giving full play to the comprehensive advantages of Guangdong-Hong Kong-Macao, docking high-standard trade and investment rules, and accelerating the cultivation of new advantages in international economic and trade cooperation [7], so as to acquire more advanced technology, take advantage of the spillover effect of reverse innovation, and comprehensively improve China's comprehensive competitiveness.

2. Literature Review

After sorting out previous literature, this paper believes that the factors affecting OFDI reverse technology spillovers can be attributed to the macro level and the micro level respectively. At the macro level, because OFDI reverse technology spillovers involve the interaction between domestic and foreign countries, Gao Xiaobo and Yin Dongdong and other scholars found that the degree of opening to the outside world will promote OFDI reverse technology spillovers [8], but limited by domestic human capital and market size, only when three factors are in the moderate range, the degree of foreign investment will have a positive impact on OFDI reverse technology spillovers [9]. Further studying its mechanism, Wang Shuli and other scholars found that the technology spillover effect comes from the technology seeking OFDI of developed economies, and there is significant regional heterogeneity [10]. Go deep into the host country. In terms of its macro economy, Ouyang Yanyan found that the per capita national income and GDP of the host country are two important factors affecting reverse technology spillovers [11]; In terms of the financial development of the host country, Du Kuanqi and other researchers found that financial scale, financial structure and financial efficiency have a threshold effect on OFDI's reverse technology spillover [12], while Sun Zhihong further explored that financial scale has a single threshold for reverse technology spillover, while financial structure and financial efficiency have a double threshold [13]. Further deepening to the aspect of absorptive capacity, Chen Yan found that the absorptive capacity of the province where the multinational company is located will determine the OFDI reverse technology spillover effect [14]. After in-depth study, Wang Feng found that the four absorptive capacity indicators of trade dependence, human capital, R&D investment and economic development level of each industry have a certain degree of promoting effect on reverse technology spillover [15]. At the level of human capital, Zhang Hong found that human capital has a significant double threshold effect on OFDI reverse technology spillover [16], while Liu Mingxia and other scholars found that human capital plays a role in the interaction between human capital and technology gap, that is, human capital only affects reverse spillover when the technology gap is small, otherwise its role is almost insignificant [17]. Similarly, Shen Fei's research results also confirmed the above conclusions, That is, the dynamic convergence of the gap between human capital and technology potential has promoted the contribution to the reverse spillover of technological innovation in the host country [18]. However, Xu Jian and other scholars gave the opposite conclusion, that is, the human capital stock did not promote the reverse technology spillover effect of OFDI, while the technology gap promoted the effect [19]. Yi Changjun and others found a new way to find the "inverted U" relationship between overseas Chinese network and OFDI technology innovation. At the level of government initiatives, research by Ruan Min and Gao Yanwei found that the institutional environment of the host country has a promoting effect on reverse technology spillovers [20], but its impact has significant regional differences [21]. Among them, the intellectual property protection system, as a policy that directly affects technological innovation, has attracted the attention of many scholars. Li Ping's research found that the impact of intellectual property protection on OFDI's reverse technological innovation is "inverted U-shaped" and the overall impact is positive [22]. When the legalization, the level of economic development and the degree of intellectual property protection reach a certain threshold at the same time, the marginal effect of reverse technology spillover effect tends to be flat [23]; However, Gao Yanwei and others made a contrary conclusion after further study, that is, intellectual property protection failed to have a positive effect on technology spillovers [21]. In addition, the government's education, science and technology support [24], the severity of corruption supervision [25] and environmental regulations [26] have all affected OFDI reverse technology spillovers to varying degrees. In terms of the technology development level of the host country, Wang Cui and other researchers found that the technology level of the host country measured by the number of patent applications and R&D investment has a significant positive correlation with reverse technology spillovers. At the micro level, Hu Zongbiao and other scholars found that enterprises' imitation learning and the degree of embedding in the host country's domestic industry chain are important factors affecting OFDI reverse technology spillovers.

As Shen Yong and other scholars said, "Guangdong-Hong Kong-Macao Greater Bay Area", as an economic form with a higher level of openness, is the leader of domestic economic development [27], and has attracted more and more scholars' attention since it was proposed. At present, scholars' research on the "Guangdong-Hong Kong-Macao Greater Bay Area" can be divided into several directions according to the object of action: in promoting economic growth, many scholars have studied the mechanism of promoting economic development in Guangdong-Hong Kong-Macao Greater Bay Area. For example, Liang Bibo once pointed out that the geographical advantages of Guangdong-Hong Kong-Macao Greater Bay Area are the foundation of its economic development, while the development of technology and institutional advantages further enable economic growth. Thus, it has a positive promoting effect. From the perspective of technology, Sun Qiangqiang and other scholars have studied that scientific and technological innovation not only promotes local economic growth, but also has a positive spillover effect on the economic development of neighboring regions [28], while Liang Jingwei and other scholars have cut in from the perspective of policy, specifically explaining that economic system rather than political system has a more significant positive regulatory effect on economic growth [29]; Peng Fangmei analyzed from the perspective of finance and found that there was a significant positive correlation between the degree of financial development and the economic growth of the Greater Bay Area [30], Zou Wei, Fu Jingyan and other scholars further studied the role of financial support, which is domestic loans and local fiscal expenditure, and green finance in promoting economic development [32]. In terms of promoting industrial upgrading, Huang Weihua and other scholars concluded that the financial development in the Guangdong-Hong Kong-Macao Greater Bay Area also has a significant role in promoting industrial upgrading [33]. In terms of driving scientific and technological innovation, many scholars first analyzed the current situation of scientific and technological development in the Guangdong-Hong Kong-Macao Greater Bay Area, and then further analyzed the mechanism. First of all, scholars such as Guo Wenwei and Feng Rui pointed out that although the efficiency of scientific and technological innovation in Greater Bay Area has gradually improved, the overall value is still low [34], and the public and market science and technology finance has shown a rapid development trend [35]; To further study the regional heterogeneity of scientific and technological innovation, Chen Zhao and Li Yan and other scholars found that the synergy of scientific and technological innovation among cities, regions and departments in Greater Bay Area is relatively low [36], but there is a clustering effect among cities close to the economy [37]. As for the mechanism of promoting the development of science and technology, financial agglomeration, as an important factor, has been concerned by many scholars. For example, Liu Gang and others have found that financial agglomeration can drive the development of high-tech industries [38]; Chen Xiangyang found that the impact of financial agglomeration on scientific and technological innovation in Greater Bay Area is an inverted U-shaped nonlinear relationship [39], while Guo Wenwei further studied the heterogeneity of the industry, and found that the financial industry agglomeration has no significant impact on regional scientific and technological innovation on the whole, but the insurance industry agglomeration has a promoting effect on scientific and technological innovation [40]; In addition, from the perspective of economic geographical factors, economic density, transportation, communication facilities, etc. will positively affect the synergy of scientific and technological innovation [36]; In terms of government support, Chen Xiangyang and Shen Minghao further studied and found that government support policies, especially fiscal support and financial support, have a positive innovation incentive effect on enterprises [41]; From the micro level, that is, enterprise behavior analysis, R&D capital and human resources are also important innovation drivers [37]. Financial agglomeration plays a key role in promoting economic development and technological innovation. Therefore, Wang Fangfang and other scholars have also studied the reasons for the change of financial agglomeration, that is, the improvement of infrastructure, etc. [42].

As mentioned above, the impact of policy factors on OFDI reverse innovation spillovers has been proved by many scholars. As a policy to promote the orderly and free flow of economic factors, efficient allocation of resources and deep integration of markets, Guangdong-Hong Kong-Macao

Greater Bay Area has a huge impact on China and the provinces along the line. First, this paper also considers the Initiative of Guangdong-Hong Kong-Macao Greater Bay Area and OFDI reverse innovation spillovers, It provides new empirical evidence for understanding the impact of Guangdong-Hong Kong-Macao Greater Bay Area on OFDI reverse innovation spillovers in provinces along the line of China; Secondly, this paper uses the difference-in-differences method to evaluate the impact of the Guangdong-Hong Kong-Macao Greater Bay Area policy on OFDI reverse innovation spillovers, and analyzes the development prospects of OFDI reverse innovation spillovers in the provinces along the line under the background of Guangdong-Hong Kong-Macao Greater Bay Area Initiative through empirical tests.

3. Model Design

The exogenous events that change the environment of individuals, manufacturers and cities in society are called natural experiments or quasi-natural experiments [43]. For a public policy, the implementation of the policy may affect some groups in the society, while the other groups will be less or even not affected. Therefore, the implementation of the policy can be compared with the exogenous events imposed on the subjects in the natural experiment. The effect of implementing the policy can be understood by comparing the group affected by the policy - the treatment group, and the group not affected by the policy - the control group. This paper regards the Guangdong-Hong Kong-Macao Greater Bay Initiative as a "quasi-natural experiment" conducted in the provinces along the line. Since the difference-in-differences method has been widely used in policy effect evaluation in recent years, this paper intends to use the double difference method to evaluate the impact of the "Guangdong-Hong Kong-Macao Greater Bay Initiative" on the development of OFDI reverse innovation spillovers in the provinces along the line. Among the 31 provinces and cities with provincial status in the Mainland of China, due to the incomplete data of Tibet, the data of Tibet are excluded in this paper. Due to the different national conditions of different countries, the policy formulation strategies and guidelines are also different. In order to more accurately control the difference between provinces and the error of estimation results due to different years, we establish a two-way fixed effect model, introducing grouping dummy variables gov_i, time dummy variables $year_t$ and the net effect of policy $gov_i \times year_t(policy)$. According to the policy spirit of the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative, we divided 30 provinces and cities into two groups, using gov_i as the grouping dummy variable, and the treatment group represents Guangzhou, a province along the "Guangdong-Hong Kong-Macao Greater Bay Area". The province's gov_i=1; and the control group is the remaining 29 provinces, gov_i=0. The time dummy variable is $year_t$, $year_t$ =0 before the proposal is put forward, and $year_t$ =1 after the proposal is put forward. Since the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative was proposed in 2015, this paper takes 2015 as the policy node. Based on the above analysis, the benchmark regression model of the difference-in- differences model is as follows:

$$S_{it}^{OFDI} = \beta_0 + \beta_1 gov_i + \beta_2 year_t + \beta_3 policy + \sum \beta_j X_j + \varepsilon_{it} \quad (1)$$

The subscripts i and t represent the i th province and year t respectively, t=0 represents 2011, t=1 represents 2012... and so on. S_{it}^{OFDI} represents OFDI reverse innovation spillover flow in each province, X represents a series of control variables, including per capita GDP, industrial structure and urbanization level of each province. ε is a random disturbance term, $gov_i \times year_t(policy)$ represents the estimate of the impact of the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative on the development of OFDI reverse innovation spillovers in the provinces along the line, which is also the variable that this paper focuses on.

Some coefficient related items in the DID model are shown in the following table. Before and after the implementation of the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative, the change effect of OFDI reverse innovation spillover in the treatment group is $S_{it}^{OFDI} = \beta_2 + \beta_3$, the change effect of OFDI reverse innovation spillover in the control group is $S_{it}^{OFDI} = \beta_2$, the change effect of OFDI reverse innovation spillover in the treatment group minus the change effect of OFDI reverse innovation spillover in the control group is the net policy effect of the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative on the development of OFDI reverse innovation spillover in the provinces along the line, That is β_3, which is the focus of this paper. The positive coefficient indicates that the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative has a positive impact on the development of OFDI reverse innovation spillovers in the provinces along the line of China. The negative coefficient indicates that the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative has a negative impact on the development of OFDI reverse innovation spillovers in the provinces along the line of China. See the following table for the meaning of specific coefficients:

Table 1. Interpretation of DID coefficient

	Before ($year_t = 0$)	After ($year_t = 1$)	Difference
Treatment Group($gov_i = 1$)	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\Delta S_{it}^{OFDI} = \beta_2 + \beta_3$
Control Group ($gov_i = 0$)	β_0	$\beta_0 + \beta_2$	$\Delta S_{it}^{OFDI} = \beta_2$
Difference	—	—	$\Delta\Delta S_{it}^{OFDI} = \beta_3$

4. Data

This paper uses China's provincial data, including panel data from 30 provinces and cities across the country (excluding Tibet) from 2011 to 2016, to measure the development level of OFDI reverse innovation spillovers in the province and to study the policy effect of the "Guangdong, Hong Kong, Macao Greater Bay Area" initiative on the development of OFDI reverse innovation spillovers. This paper takes 2011 as the base period to carry out value adjustment for the data calculated by price. All the data are calculated after sorting out the data in the *Statistical Yearbook of China's Foreign Trade and Economic Cooperation*, the National Bureau of Statistics and the statistical yearbook of each province.

5. Variable Selection

5.1 Explained Variable

This paper uses variable S_{it}^{OFDI} to express OFDI reverse innovation spillover. Referring to the construction method of OFDI reverse innovation spillover index by Lichtenberg & Potterie [44], Li Mei and Liu Shichang [45], the following model is obtained:

$$S_t^{OFDI} = \sum \frac{OFDI_{jt} \times S_{jt}}{Y_{jt}} \tag{2}$$

Among them, S_{it}^{OFDI} is China's R&D capital stock obtained through outward direct investment channels in the t period, and is also the explained variable of this study. $OFDI_{jt}$ is the outward direct

investment flow of our country to the host country j during the t period. S_{jt} is the R&D capital stock of country j in t period. Y_{jt} is the GDP of country j in the period t. In the selection of host countries for outward direct investment, because technology-oriented outward direct investment mostly occurs in developed countries. Through comprehensive consideration of the flow of OFDI in China, the amount of R&D capital stock in various countries and the availability of data, this paper selects 17 countries or regions, including the United States, Canada, Russia, Germany, France, the United Kingdom, Italy, South Korea, Japan, Singapore, Israel, Poland, Denmark, Sweden, the Netherlands, Belgium, and Hong Kong, as the research objects. In this model, $OFDI_{jt}, Y_{jt}$ data can be obtained from the Statistical Yearbook of China's Foreign Trade and Economic Cooperation and the World Bank website respectively, S_{jt} is calculated based on the R&D input of 17 countries or regions during the sample period (2011-2016). First of all, the percentage of the total domestic R&D expenditure in GDP of these 17 countries and regions can be found on the World Bank website, then multiplied by the GDP of each country, and converted into the actual R&D expenditure at constant prices in 2011 using the consumer price index. Finally, the R&D capital stock of country j in the period t can be obtained according to the perpetual inventory method.

In order to measure the reverse spillover effect of outward direct investment of each province, this paper adds the weight of each province, which is expressed by the sum of the OFDI stock of each province in the national OFDI stock each year. Foreign R&D spillovers from foreign investment can be expressed as:

$$S_{it}^{OFDI} = S_t^{OFDI} \times \frac{OFDI_{it}}{\sum_i OFDI_{it}} \tag{3}$$

Among them, i refers to 30 provinces, S_{it}^{OFDI} is the reverse spillover effect of the outward direct investment of province i in the period t, S_t^{OFDI} is the R&D capital stock obtained through the outward direct investment channel in China in the t period, and $OFDI_{it}$ is the outward direct investment flow of i province in the t period.

5.2 Key Explanatory Variables

Since this paper considers the policy effect of the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative, the grouping dummy variable gov_i along the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative, the time dummy variable $year_t$ proposed by the "Guangdong-Hong Kong-Macao Greater Bay Area" initiative, and the interaction term $gov_i \times year_t(policy)$ will use as the core explanatory variable, of which the coefficient of the interaction term is the main variable concerned in the study.

5.3 Control Variables

According to the previous literature analysis and logical framework, a series of other factors affecting the development of OFDI reverse innovation spillovers in the province are selected as control variables, including per capita GDP, industrial structure and urbanization level of each province. See Table 2 for the definition and interpretation of specific variables:

Table 2. Variable definition table

Variable Name	Meaning of Variables	Variable Calculation Method
S_{it}^{OFDI}	OFDI reverse nnovation spillover	See the previous section for details
gov_i	Group variables	Control group is 0, treatment group is 1

$year_t$	Time variable	0 before and 1 after the proposal
$gov_i \times year_t\,(policy)$	Net effect of policy	Multiplying grouping variables and time variables
pergdp	Per capita GDP of each province	Actual value of per capita GDP of each province (unit: yuan)
industry	Industrial structure of each province	Added value of tertiary industry in each province/GDP of the province
urban	Urbanization level of each province	Urban population of each province/total population of the province
fin	Provincial financial development	Balance of deposits and loans of financial institutions in each province/GDP of the province

6. Empirical Analysis Results

6.1 Descriptive Statistical Results of Variables

Before the regression analysis, this paper first carries out descriptive statistical analysis on 180 data, and the results are shown in Table 3:

Table 3. Descriptive statistical results

Variable	Obs	Mean	Std. Dev.	Min	Max
S_{it}^{OFDI}	180	1.66×10^8	3.09×10^8	314674	2.50×10^9
pergdp	180	46202.04	20535.79	16413	105568.69
industry	180	0.44	0.09	0.30	0.80
urban	180	0.56	0.13	0.35	0.90
fin	180	3.01	1.15	1.52	8.13

From the above table, it can be preliminarily judged that during the sample observation period 2011-2016, there is a large gap between the OFDI reverse innovation spillover level and the minimum and maximum per capita GDP of 30 provinces. Therefore, the economic development level and OFDI reverse innovation spillover level of 30 provinces have significantly improved during the observation period, and the difference between different provinces is large.The preliminary results show that the release of the policy of Guangdong-Hong Kong-Macao Greater Bay Area may promote the development of OFDI reverse innovation spillovers.

6.2 Correlation Analysis

Table 4. Correlation Analysis Results

Variables	(1) S_{it}^{OFDI}	(2) pergdp	(3) industry	(4) urban	(5)fin
(1) S_{it}^{OFDI}	1.000				
(2) pergdp	0.535	1.000			
(3) industry	0.503	0.645	1.000		
(4) urban	0.508	0.936	0.725	1.000	
(5) fin	0.396	0.479	0.868	0.578	1.000

The control variable usually has a high correlation with the dependent variable of the regression equation. In order to verify the high representativeness of the control variables selected in this paper, we conducted a correlation analysis on the relationship between the control variables and the dependent variables, and the results are shown in the table 4:

It can be seen from the table that the correlation coefficient between the development level of OFDI reverse innovation spillover and the four control variables is large, which proves that the control variables selected in this paper are highly effective.

6.3 Parallel Trend Test

In order to visually examine whether the Guangdong-Hong Kong-Macao Greater Bay Initiative has an impact on the OFDI reverse innovation spillover effect in the provinces along the line, this paper plans to draw a comparison chart of the time trend of the OFDI reverse innovation spillover effect in the experimental group and the control group, and observe the change trend of the OFDI reverse innovation spillover effect in the two groups of provinces.

After calculating the mean value of OFDI reverse innovation spillover effects of two groups of OFDI reverse innovation spillover effects, the time trend chart of provinces along the Guangdong-Hong Kong-Macao Great Bay Initiative and non-provinces along the line is drawn as shown in the figure below (see Figure 1). From Figure 1, it can be seen that the change trend of OFDI reverse innovation spillover effects of the processing group and the control group is roughly the same before the implementation year of Guangdong-Hong Kong-Macao Great Bay Region policy 2015. Therefore, it can be preliminarily judged that the two groups basically meet the time trend assumption before the year of policy implementation.

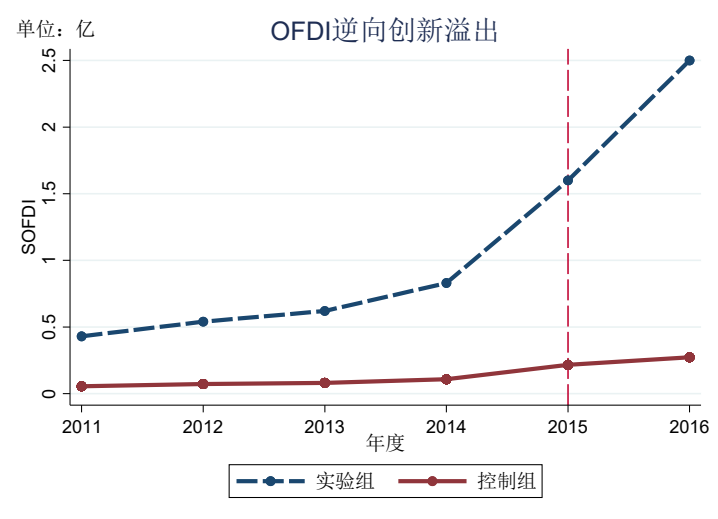


Figure 1. Parallel trend chart

In order to further prove whether there is a significant difference in OFDI reverse innovation spillover level between provinces along the Guangdong-Hong Kong-Macao Greater Bay Initiative and non-provinces along the line in 2011-2014, this paper constructs the multiplier terms of time dummy variable and grouping variable policy2011, policy2012, policy2013, policy2014, policy2016, and modifies the corresponding policy years to 2011, 2012, 2013 2014 and 2016 are used to test the parallel trend of OFDI reverse innovation spillover level in the provinces along the policy line and non-provinces along the policy line from 2011 to 2014. The new regression equation is constructed as follows.

$$S_{it}^{OFDI} = \beta_0 + \beta_1 \times policy + \beta_2 \times policy2012 + \beta_3 \times policy2013 + \beta_4 \times policy2014 + \beta_5 \times policy2016 + \sum \beta_j X_j + \varepsilon_{it} \quad (4)$$

The regression results are shown in Table 5. It can be seen from Table 5 that at the 5% significance level, the variables policy2011, policy2012, policy2013 and policy2014 are not significant, indicating that the OFDI reverse innovation spillover level of provinces along the policy line and non-provinces along the policy line has a good parallel trend between 2011-2016, and can be regressed by using the difference-in-differences model. At the same time, the policy result of the policy net effect variable is significant, which preliminarily proves that the Guangdong-Hong Kong-Macao Greater Bay Initiative has played a certain role in promoting the development of OFDI reverse innovation spillovers in the provinces along the line.

Table 5. Parallel trend test

	S_{it}^{OFDI}
policy	$7.9\times10^{8***}$
	(0.0000)
policy2016	$7.4\times10^{8***}$
	(0.0000)
policy2014	$2.1\times10^{8*}$
	(0.0936)
policy2013	8.5×10^{7}
	(0.4849)
policy2012	8.1×10^{7}
	(0.5051)
policy2011	0.0000
	(.)
pergdp	$3.4\times10^{4***}$
	(0.0000)
industry	4.7×10^{8}
	(0.2739)
urban	$-6.7\times10^{9***}$
	(0.0000)
fin	$2.2\times10^{8***}$
	(0.0000)
Provincial fixed effect	YES
Time fixed effect	YES
_cons	$1.5\times10^{9**}$
	(0.0272)
N	180
r2_w	0.8665

p-values in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Note: t test statistics are in brackets

6.4 Benchmark Regression Results

After verifying the validity of the data, we will further study the relationship between the proposed policy of Guangdong-Hong Kong-Macao Greater Bay Area and the development of OFDI reverse innovation spillovers. We carry out panel fixed effect regression for formula (1), and the results of the difference-in- differences model regression are listed in Table 6.

Table 6. Benchmark regression results

	(1) S_{it}^{OFDI}	(2) S_{it}^{OFDI}	(3) S_{it}^{OFDI}	(4) S_{it}^{OFDI}	(5) S_{it}^{OFDI}
policy	$1.3\times10^{9***}$	$1.1\times10^{9***}$	$1.2\times10^{9***}$	$1.1\times10^{9***}$	$1.1\times10^{9***}$
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
pergdp		$4.2\times10^{4***}$	$4.6\times10^{4***}$	$2.6\times10^{4***}$	$3.4\times10^{4***}$
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
fin		$3.8\times10^{8***}$	$3.7\times10^{8***}$		$2.2\times10^{8***}$
		(0.0000)	(0.0000)		(0.0002)
industry			$3.4\times10^{9**}$	4.3×10^{8}	4.2×10^{8}
			(0.0122)	(0.3964)	(0.3805)
urban				$-8.2\times10^{9***}$	$-7.0\times10^{9***}$
				(0.0000)	(0.0000)
Provincial fixed effect	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES
_cons	$6.8\times10^{7***}$	$-2.6\times10^{9***}$	$-3.3\times10^{9***}$	$3.2\times10^{9***}$	$1.7\times10^{9**}$
	(0.0135)	(0.0000)	(0.0000)	(0.0000)	(0.0221)
N	180	180	180	180	180
r2_w	0.5572	0.7437	0.7549	0.8092	0.8271

p-values in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Note: t test statistics are in brackets

In Table 6, the (1) column shows the regression results of the financial development of each province without the introduction of control variables, and the (2) column shows the regression results with introducing the financial development of each province as the control variable, The (3) column shows the results of introducing the financial development and industrial structure of each province, the (4) column shows the results of introducing the urbanization level and industrial structure of each province, and the (5) column shows that all control variables are introduced into the regression equation. According to Table 6, without considering the control variables, at the significance level of 1%, we have sufficient evidence to show that the policy net effect variable policy has a significant relationship with OFDI reverse innovation spillover, with a value of 1.3×10^{9}, indicating that the Guangdong-Hong Kong-Macao Greater Bay Initiative has a significant positive effect on OFDI reverse innovation spillovers in the provinces along the line, that is, the Guangdong-Hong Kong-Macao Greater Bay Initiative significantly promotes the development of OFDI reverse innovation spillovers in the provinces along the line. In the process of continuously introducing control variables, we can see that the policy coefficient of the policy net effect variable is always significant at the level of 1% significance, which proves that the result is robust.

6.5 Dynamic Test

In order to further study the impact time of the Guangdong-Hong Kong-Macao Greater Bay Initiative on the OFDI reverse innovation spillover effect in the provinces along the line, this paper conducts a dynamic test on the basis of the above to determine whether the impact effect of the policy is still significant in 2016 after the implementation of the policy. Assuming that the implementation time of its policy is 2016, we use the variable policy2016 to test with the difference-in-differences

model (see Table 7 for the results). According to the table results, at the significance level of 1%, we have sufficient evidence to prove that the variable policy2016 is significant, and its coefficient value is 7.4×10^8, greater than policy coefficient 6.9×10^8, indicating that the Guangdong-Hong Kong-Macao Greater Bay Initiative still has a good impact on the OFDI reverse innovation spillover effect in the provinces along the line in the second year, and the positive impact continues to deepen.

Table 7. Dynamic test results

	S_{it}^{OFDI}
policy	$6.9\times10^{8***}$
	(0.0000)
policy2016	$7.4\times10^{8***}$
	(0.0000)
pergdp	$3.3\times10^{4***}$
	(0.0000)
industry	4.3×10^{8}
	(0.3122)
urban	$-6.8\times10^{9***}$
	(0.0000)
fin	$2.2\times10^{8***}$
	(0.0000)
Provincial fixed effect	YES
Time fixed effect	YES
_cons	$1.6\times10^{9**}$
	(0.0149)
N	180
r2_w	0.8636

p-values in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$
Note: t test statistics are in brackets

6.6 Elimination of the Impact of Other Events

Due to the fact that in the same period of time, countries or different provinces may introduce other policies to promote or inhibit OFDI reverse innovation spillovers, the results of the cross-product coefficient generated by the regression may have a large or small error, which leads us to overestimate or underestimate the impact of Guangdong-Hong Kong-Macao Greater Bay Area policy on OFDI reverse innovation spillovers. In order to further eliminate other policy interference, this paper has eliminated the provinces along the *Outline of Yangtze River economic belt development* proposed at the same stage as the Guangdong-Hong Kong-Macao Greater Bay Initiative.

The Outline of Yangtze River economic belt development is a programmatic document approved by the Political Bureau of the CPC Central Committee in March 2016. It clearly puts forward the requirements of promoting the transformation and upgrading of innovation-driven industries and striving to build a new pattern of all-round opening up, which may have a positive impact on OFDI's reverse innovation spillovers. Therefore, in this stage of regression, we have eliminated 11 provinces and cities covered by the Yangtze River Economic Belt, including Shanghai, Jiangsu, Zhejiang and

Anhui, and the sample size has been reduced from 180 to 114. According to the above steps, we have conducted the double difference model test again. The experimental results are as follows (see Table 8 for the results).

Table 8. Regression results after excluding provinces along the Yangtze River Economic Belt

	(1) S_{it}^{OFDI}	(2) S_{it}^{OFDI}	(3) S_{it}^{OFDI}	(4) S_{it}^{OFDI}	(5) S_{it}^{OFDI}
policy	$1.3\times10^{9***}$	$1.2\times10^{9***}$	$1.2\times10^{9***}$	$1.1\times10^{9***}$	$1.1\times10^{9***}$
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
pergdp		$3.0\times10^{4***}$	$3.3\times10^{4***}$	$2.5\times10^{4***}$	$2.9\times10^{4***}$
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
fin		$1.5\times10^{8**}$	$1.5\times10^{8**}$		$1.2\times10^{8*}$
		(0.0362)	(0.0405)		(0.0862)
industry			8.2×10^{8}	6.4×10^{8}	6.0×10^{8}
			(0.2822)	(0.3801)	(0.4049)
urban				$-4.4\times10^{9***}$	$-4.1\times10^{9***}$
				(0.0005)	(0.0011)
Provincial fixed effect	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES
_cons	$6.9\times10^{7**}$	$-1.6\times10^{9***}$	$-2.0\times10^{9***}$	1.1×10^{9}	5.0×10^{8}
	(0.0166)	(0.0000)	(0.0003)	(0.1805)	(0.5799)
N	114	114	114	114	114
r2_w	0.7115	0.8049	0.8075	0.8242	0.8303

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Note: t test statistics are in brackets

In Table 8, the meaning of regression results in columns (1) to (5) is the same as that in Table 6. According to Table 8, whether the control variable is considered or not, at the significance level of 1%, we have sufficient evidence to show that the relationship between the policy net effect variable policy and OFDI reverse innovation spillovers is still significant, indicating that the Guangdong-Hong Kong-Macao Greater Bay Initiative itself does have a significant positive effect on OFDI reverse innovation spillovers in the provinces along the line, and the conclusion is not affected by the promulgation of *the Outline of Yangtze River economic belt development*.

7. Conclusion, Inspiration and Suggestions

7.1 Conclusion

Based on the panel data of 30 provinces and cities across the country from 2011 to 2016, this paper explores the impact of the Guangdong-Hong Kong-Macao Greater Bay Area Initiative on the development of OFDI reverse innovation spillovers in the provinces along the line, and empirically tests the impact of the Guangdong-Hong Kong-Macao Greater Bay Area Initiative on the development level of OFDI reverse innovation spillovers in the provinces along the line using the difference-in-differences method. The study found that the Guangdong-Hong Kong-Macao Greater Bay Initiative has effectively improved the development level of OFDI reverse innovation spillovers in the provinces along the line in China. From the dynamic test results, it can be seen that the Guangdong-Hong Kong-Macao Greater Bay Initiative has started to have an impact on the development of OFDI reverse innovation spillovers in the provinces along the line since it was proposed, and the policy effect has been gradually strengthened, and the significant level has been

continuously improved. Subsequently, this paper eliminated the sample values of 11 provinces included in the Yangtze River Economic Belt to exclude the impact of exogenous events, and the test results further verified the robustness of the regression results, indicating that the promotion of the policy of Guangdong-Hong Kong-Macao Greater Bay Region on the development level of OFDI reverse innovation spillovers in the provinces along the line is not affected by other policy factors.

7.2 Inspiration

First, continue to steadily promote the construction of the world-class urban agglomeration of "Guangdong, Hong Kong and Macao Greater Bay Area", and form a national regional development demonstration effect. The "Guangdong-Hong Kong-Macao Greater Bay Area" initiative is an important exploration of China's new system of open economy. The country should increase its support for OFDI reverse innovation spillover to promote the improvement of OFDI reverse innovation spillover level. In order to build the regional economic integration of Guangdong, Hong Kong and Macao, we must solve the contradictions and conflicts caused by two systems, three tariff zones and three legal systems. Strong policy and institutional guarantee is the basis for realizing the beautiful vision of "Guangdong, Hong Kong and Macao Greater Bay Area". We should adhere to the reform guidance and innovation drive, and strive to break the administrative barriers in Guangdong, Hong Kong and Macao. Adhere to coordinated development, make overall consideration, make effective use of administrative means, build policy connectivity among the three regions, connect people's hearts, and achieve the goal of convenient circulation of elements, efficient allocation of resources and coordinated development of industries.

Second, regions along the "Guangdong-Hong Kong-Macao Greater Bay Area" should further strengthen OFDI cooperation with foreign countries, integrate OFDI resources and implement OFDI projects. As an important support for China's "the Belt and Road" initiative, the construction of the "Guangdong Hong Kong Macao Greater Bay Area" should give full play to policy and regional advantages, thoroughly implement the "go global" and "bring in" strategies, and increase cooperation with OFDI projects in countries along the "the Belt and Road". Chinese enterprises' overseas investment and M&A are distributed in 68 countries (regions) around the world. Strengthening OFDI cooperation with foreign countries is an important thrust to realize the " dual circulation " at home and abroad. By increasing OFDI to countries with high economic development level and emerging economies, we can effectively obtain more advanced technology and management experience of the invested countries, and promote the improvement of innovation capacity of the home country.

Third, strengthen the construction of supporting services and measures in the fields of system, education, finance, etc., create a good environment for creating a new round of characteristic opening-up areas, and realize benign interaction and circulation. Relevant departments should strengthen the construction of OFDI support system, create a strong and loose institutional environment, provide sufficient financial support for small and medium-sized enterprises participating in OFDI, reduce the cost of foreign investment, improve the enthusiasm and initiative of enterprises to "go global", and further expand the scale of OFDI in China. At the same time, paying attention to scientific and technological innovation and enhancing the absorptive capacity of enterprises to new technologies are important ways to improve the spillover effect of OFDI's reverse innovation.

Fourth, the Guangdong-Hong Kong-Macao Greater Bay Area policy has significantly promoted the development of foreign direct investment in the provinces along the line, and has promoted the level of opening up of the provinces along the line. The Guangdong-Hong Kong-Macao Greater Bay Area is capable of being the "new pivot" of the next round of opening up to promote regional financial development and scientific and technological progress. The level of financial development is an important factor affecting OFDI reverse innovation spillovers. China should continue to encourage and strengthen the construction of various forms of open areas such as the "Bay Area" and "Economic Belt", and combine administrative tools and economic means to promote and radiate the opening up of a larger area by significantly improving the level of opening up in some regions.

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