The Effect of Government Subsidy Policy for Foreign Capital R&D from the Perspective of Global Supply Chains: An Empirical Analysis with Time Lag and Propensity Score Matching

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Abstract: (1) Background: with the emergence and continuous development of more multinational corporations, capital and resources flow rapidly in the form of global supply chains around the world. Furthermore, government subsidies for R&D are one of the key factors that affect foreign-funded R&D activities and their innovation output and performance in global supply chains. (2) Methods: in this paper, firstly, based on two sets of time series and dynamic panel data, we propose a distribution time lag model to test the effect of R&D subsidy policies from the macro perspective. Secondly, we employ the propensity score matching method to test the micro effect of R&D subsidy policies. (3) Results: our empirical results show that there are significant differences in the impacts of R&D subsidy policies on foreign capital R&D and domestic innovation. The main effect of government subsidy on foreign capital R&D is to improve the innovation output. However, regarding domestic R&D, it is to promote innovation performance. (4) Conclusions: Government subsidy is the main cause of the individual differences among the foreign funded R&D institutions in terms of innovation output and innovation performance. From the perspective of global supply chains, our analysis and results provide managerial and policy insights on subsidizing foreign investment in R&D in China.

Keywords: foreign investment in R&D; government R&D subsidy; innovation output; innovation performance; propensity score matching

1. Introduction

Global supply chains are generally complex, with multiple suppliers, distributors, and products located in different countries or regions. Product R&D activities are conducted in supply chains across many countries [1]. Supply chain extension is a process in which the core enterprises of a supply chain start from a certain link with comparative advantage, continue to expand to related links upstream and downstream, and finally form a supply chain covering longer and more valuable creation links. Vertical global supply chains extend the R&D, design, production, and sales of enterprises to foreign countries [2,3]. For example, with the continuous development of China’s economy, especially after its entry into the WTO, multinational companies have extended their supply chains through sole proprietorship or joint venture with Chinese enterprises. These multinationals often set up R&D centers and increase R&D investment in China [4,5]. The early demonstration effect and spillover effect of foreign R&D have a positive impact on the formation and
promotion of China’s domestic innovation capability [6]. Governments also encourage foreign firms to increase their R&D investment with policy tools such as personal income tax refunds and business tax reductions [7]. However, as one of the most effective policies to stimulate innovation, direct subsidies for foreign-invested R&D activities in China are still lacking. In contrast, domestic innovation entities, especially research institutions or domestic enterprises in strategic or emerging industries, are more likely to receive direct government funding support. At first instance, the government’s directly subsidizing domestic innovators may not influence foreign firms’ decision making. However, their innovative activities can be influenced by their domestic partners in the form of R&D alliances and joint research centers/institutes [8].

With the restructuring of the economy, the relationship between foreign-invested R&D and domestic innovation has taken on new features. Firstly, with the emergence of government subsidies and other incentives, China’s domestic innovation capacity has been significantly enhanced, and the marginal effect of the positive spillover from foreign-invested R&D has been diminished. Secondly, with network embedding, foreign-invested R&D has become one of the most important elements of innovation ecology in China. As a result, the boundary of foreign-invested R&D that depends on its parent company has become increasingly blurred with the symbiosis and co-performance of its domestic innovation partners. To a certain extent, government R&D subsidies have helped reduce innovation risk caused by asymmetric market information and technological innovation externality.

As a policy signal, the government subsidizes foreign-funded R&D entities in China through various methods, such as project completion incentives, tax reductions, or post-export tax rebates. This incentivizes companies to increase innovation investment and strengthen cutting-edge technology exploration. As a regulatory mechanism, the government subsidizes and coordinates cooperation among R&D entities by enhancing their willingness to cooperate, resolving major conflicts, and establishing trust.

At present, the following views have been proposed on the influence of government subsidies on innovation activities and the value creation of collaborative innovation in global supply chains. Firstly, as a transmission signal, government subsidy affects investment in private R&D. For example, Kleer (2012) [9] and Sun et al. (2017) [10] believe that, as a transmission signal, government subsidy stimulates innovators to increase R&D investment and improve its endogenous power to develop cutting-edge and high-risk technology, and ultimately strengthen its innovation ability. Secondly, government regulations may hinder companies’ innovation or make them dependent on subsidy excessively, especially when they are in unequal status with asymmetric information. This may cause power rent seeking or make it difficult for enterprises to realize effective subsidy benefits. In the literature, corporate governance variables such as ownership nature and equity structure are shown to be the determinants that influence government subsidy policy and its effectiveness [11–13].

State-owned enterprises have special market status and political connections, and it is easier for them to obtain government subsidies. Subsidizing the R&D activities of state-owned enterprises has become the main method for the government to support domestic innovation [14]. At the same time, in order to enhance the vitality of domestic innovation, both central and local governments have also set up innovation funds to support or incubate small- and medium-sized technology-based enterprises. Government subsidies have also shifted from traditionally key industries to enterprises or R&D institutions with innovation potential and capabilities. Thirdly, Mao and Xu (2015) [15] adopt the three-stage dynamic game model proposed by Deng and Wu (2017) [16], and argue that the level of government subsidy should be within an appropriate range. Both under-subsidy and over-subsidy can negatively affect innovation. At the same time, the effect of government subsidies is also affected by the size or growth stage of an enterprise. In general, the effects on small and medium-sized enterprises using government subsidies for product development and technological innovation are more pronounced [17–19].
Another problem worthy of attention is that the inherent weakness of the R&D capabilities of SMEs may make government subsidies ineffective. Thus, several scholars have proposed that government finance should support the innovation of SMEs and encourage them to build links with R&D institutions such as universities [20–22]. The existing empirical and qualitative research has outlined a logical framework of the influence of government R&D subsidies on enterprise innovation and the value creation of collaborative innovation in global supply chains from the perspectives of signaling, policy dependence, and subsidy level design. However, most studies are limited to the mechanism by which domestic enterprises obtain government subsidies which promote or inhibit domestic innovation.

Foreign R&D centers in China are innovation entities with high heterogeneity and that are under the control of foreign parent companies. The influences of government R&D subsidy on their innovation performance and innovation output are different from those of domestic enterprises. Our research in this paper investigates the characteristics of foreign capital R&D innovation activities in China in the presence of R&D subsidies. In particular, we use innovation output and innovation performance as dependent variables. First, we apply time-series data to construct a time-lag model of foreign R&D innovation output and innovation performance under government subsidy policies, and test their macro effects. Second, we employ dynamic panel data and the PSM method to infer whether government subsidy’s effects are significant through counterfactual inference, i.e., whether it is the main cause of individual differences in innovative output and innovative performance.

2. Research Design and Data Acquisition

2.1. Variable Selection

In what follows, we describe the process of selecting both dependent and independent variables.

The paper takes innovation output and innovation performance as dependent variables. Exclusive use of new technologies through patent protection can ensure benefits for inventors. Hence, the number of invention patents granted can reflect innovative output directly. Sales revenue of new products reflects the vitality of enterprise innovation and is a reliable indicator of innovation performance.

Next, we present the independent variables. Labor force and capital input are the key elements of innovation activities. People engaging in R&D in enterprises and institutions are chosen as the measurement of labor input (equivalent persons in macro-analysis). According to the funding source for innovation, R&D capital investment can be divided into two categories: internal capital investment and external capital investment (such as government subsidies). For the innovators, subsidies are not only a tool for the government to support technology development, but also a part of its capital element investment. Therefore, labor, internal capital, and government subsidies are chosen as independent variables.

2.2. Model Development

Next, we construct an empirical model from both macro and micro levels to test the effect of government subsidies on foreign funded R&D in China from the perspective of global supply chains.

2.2.1. Time-Lag Distribution Model

The macro-effect test of government subsidies is based on the time series data of foreign investment in R&D and innovation investment and output in China. Because the influence of input factors on innovation output has time lag, a model of time distribution lag is constructed. From the perspective of government subsidy, a time-series regression model is constructed as:

\[
\ln(output)_t = \alpha + \delta_t \ln(Persons)_t + \beta_1 \ln(Self.Fund)_t + \sum \beta_i \ln(GovSubsidy)_{t-1} + \varepsilon_t \tag{1}
\]
In Equation (1), the independent and dependent variables are both natural logarithm forms. Model (1) not only takes government subsidy as an important explanatory variable, but also considers the hysteresis of its influence on innovation output. In (1), \( t \) represents year, \( i \) the hysteresis, and \( e \) the random error term. Output includes the two dependent variables of innovation output and innovation performance.

2.2.2. Propensity Score Matching

Propensity Score Matching (PSM) has been employed to test the micro-mechanism of government subsidy affecting foreign R&D innovation. PSM is an effective method to reduce sampling confounding bias and has been widely adopted in economics and social sciences. It aims to use non-experimental data (control data) to analyze the intervention effect, and it can effectively avoid potential endogenous problems caused by sample selection bias [23,24]. As a “counterfactual” inference method, the PSM assumes that the causal relationship between the research objects is the result of both observed and unobserved conditions (i.e., stating that fact A is the reason for B and analyzing what B will produce if A does not occur).

In this study, there may be a mixed bias in the causal inference between government subsidy and foreign R&D innovation outputs. That is, it is difficult to determine whether the difference in the R&D innovation performance of foreign capital in China (measured by sales revenue of new products) is caused by the differences within individuals or by the government’s role (measured by R&D subsidies).

Using the method of bias score matching, the sample was divided into experimental groups. The experimental group consists of foreign R&D institutions that had received a government R&D subsidy. The control group consists of foreign-funded R&D institutions that had not received a government subsidy. Using government subsidy as a grouping variable, we explore the systematic statistical differences between institutions with and without R&D subsidies with the following model:

\[
Y_i = Y_i(\text{Gov.Subsidy}) = \begin{cases} 
Y_i(0), & \text{if Gov.Subsidy} = 0 \\
Y_i(1), & \text{if Gov.Subsidy} = 1 
\end{cases}
\]

where \( Y_i(1) \) represents innovative output and innovative performance with government subsidy, and \( Y_i(0) \) indicates innovative output and innovative performance without government subsidies. The difference between the above variables in the two scenarios, namely the average processing effect (ATT), can be expressed as:

\[
\text{ATT} = E\{Y_i(1) - Y_i(0)|\text{Gov.Subsidy} = 1 \}
\]

2.2.3. Data Collection and Processing

(1) Time-series data collection and processing

The time-series data mainly come from the “China Science and Technology Statistics Yearbook”, “China Statistics Yearbook”, and “Compilation of Statistical Data of Institutions of Higher Education”, as well as several research studies on foreign capital in China [25–30].

It should be noted that, before 2008, the “China Science and Technology Statistical Yearbook” did not include the expenditure sources in the internal expenditures of R&D funds for enterprises, universities, and research institutions. Enterprises usually will not use up all the R&D funds secured in technology and product development activities. For example, some R&D funds can be utilized to improve the associated services. In this research, after surveying and consulting with the 316 foreign-funded R&D institutions in our sample, the internal expenditures of the R&D funds before 2008 are calculated as 40% of the total R&D funds raised. Furthermore, we can eliminate the direct impact of the 2008 financial crisis on the R&D investments of domestic and foreign enterprises, as they are synchronous in terms of the fluctuation of R&D investment and inflation rate, as argued in [31]. In addition, the “China Science and Technology Statistics Yearbook” and “Compilation of Statistical Data of Colleges and Universities” contain the data of
government funding in R&D activities, the number of invention patents granted, and R&D personnel equivalents. However, there were no data of sales revenue of new products, which was then replaced in this study by the annual revenue of the commercialization of college research findings.

(2) Panel Data Acquisition and Processing

It is necessary to obtain micro-data at the level of innovation entity (enterprise or R&D institution) to explore how government subsidies affect the embedding of foreign investment in R&D, as well as its R&D investment and output.

The following data were collected through a questionnaire. The structure of the questionnaire is as follows. The first part mainly includes the industry, establishment time, and main layout of foreign R&D institutions in China under global supply chains. The second section, the foreign input and output data in China, covers the yearly number of people engaging in R&D, self-owned funds (enterprise funds), new product sales revenue, and the number of invention patents granted. The research needs to collect dynamic panel data on foreign investors in China from 2015 to 2017. To this end, this research adopted a follow-up survey. The specific process was as follows.

Firstly, with the help of the Ministry of Commerce, the Ministry of Science and Technology, and the official website of the Department of Commerce of some provinces, cities, and autonomous regions, the registered information of foreign companies was obtained, including the name, address, and source country of capital.

Secondly, in 2015, members of the research group randomly selected 55 representative foreign-funded R&D institutions in Beijing, Shanghai, and Suzhou, where foreign-funded R&D institutions are concentrated. We conducted face-to-face interviews with these institutions. After obtaining the initial samples, we sent a questionnaire to a randomly selected list of foreign-funded enterprises or R&D institutions using tools such as email and social media (e.g., WeChat). In this way, we obtained data from 261 more institutions. Eventually, we had a sample of 316 foreign-funded R&D institutions in China.

In order to avoid possible data inconsistency and incompleteness in data collection over the years, the data collected for each year were treated as follows. The data collected annually were filtrated based on the name of the R&D institutes and the location of registration to ensure that the sample could be observed continuously within three years. Then, incomplete data were removed to ensure data integrity. Finally, in order to eliminate the influence of the variable dimension on empirical analysis at the macro level, the dimension of each indicator was eliminated in data use. Furthermore, the natural logarithm of the index data obtained from the questionnaire was taken.

3. Empirical Tests and Results

3.1. Macro-Effect Test of Foreign Capital Affected by Government Subsidy in R&D

The time-lag distribution model can capture the dynamic analysis between the variables mentioned above. However, it also introduces more complex estimation problems, especially because of the uncertainty regarding lag period. Applying the ordinary least squares method (OLS), we would inevitably have to explain whether there exists autocorrelation or multicollinearity among the variables. The method of Koyck transformation can effectively alleviate these problems and test the distribution lag model. Hence, the following transformation is performed on Equation (1). Assume that the influence of the distribution hysteresis on the variable will attenuate with time, if \( \beta_k = \beta_0 \lambda^k \), \( \gamma \) is the attenuation rate of the variable coefficient over time, and \( 1 - \gamma \) represents the time adjustment rate. Substituting \( \beta_k = \beta_0 \lambda^k \) into Equation (1) yields:

\[
\ln(\text{output})_t = \alpha + \delta_t \ln(\text{Persons})_t + \eta_t \ln(\text{Self.Fund})_t + \sum_k \beta_0 \lambda^k \ln(\text{GovSubsidy})_{t-k} + \epsilon
\]  

(4)

The equation of the delayed one period can be further expressed as:

\[
\ln(\text{output})_{t-1} = \alpha + \delta_{t-1} \ln(\text{Persons})_{t-1} + \eta_{t-1} \ln(\text{Self.Fund})_{t-1} + \sum_k \beta_0 \lambda^k \ln(\text{GovSubsidy})_{t-1-k} + \epsilon
\]  

(5)
Based on Equations (4) and (5), we have:

\[
\ln(\text{output})_t = \left\{ (1 - \lambda)\alpha + \ln(\text{Persons})_t - \lambda \ln(\text{Persons})_{t-1} + \eta \ln(\text{Self}.\text{Fund})_t - \lambda \eta \ln(\text{Self}.\text{Fund})_{t-1} + \ln(\text{output})_{t-1} + \epsilon \right\}
\]

(6)

Then, the regression problem of Model (1) is transformed into the problem of estimating and testing the auto-regression model of Model (4). The transformed Model (4) has two new independent variables, the lag items of R&D personnel input and self-funded input. We applied Eviews 9.1 to test Models 1 and 2 (as shown in Table 1), where model 1 is based on the testing of data related to foreign R&D and Model 2 is based on the testing of data related to domestic innovation. The dependent variables of Model 1-1 and Model 2-1 are innovation outputs measured by the number of invention patents granted. The dependent variables of Model 1-2 and Model 2-2 are the innovation performances measured by new product sales revenue. As can be seen from Table 2, while government R&D subsidy affects the output of invention patents, it also has a significant and positive regulatory effect on a firm’s own capital investment. The impact and adjustment coefficients have passed the significance test at the 0.05 level. The delayed phase of government R&D subsidies has an insignificant impact on the output of invention patents and corrected standard errors. At the same time, it should be noted that Equation (6) is an autoregressive model. Therefore, it is difficult to directly estimate the possible autocorrelation.

Table 1. Parameter estimations and tests using single-equation models.

| Independent Variables | Model 1 (Foreign Capital R&D) | Model 2 (Domestic Innovation) |
|-----------------------|-----------------------------|-------------------------------|
|                       | Model 1-1 (Output) | Model 1-2 (Performance) | Model 2-1 (Output) | Model 2-2 (Performance) |
| C                     | 0.1556          | 6.7547                        | -8.7175 ***       | 3.2474 *               |
|                       | (4.4104)        | (1.0885)                      | (2.3750)          | (1.5452)               |
| NS\_t-1              | 0.8702          | 0.2209 *                      | 0.4186            | 0.1555                 |
|                       | (0.4914)        | (0.1527)                      | (0.2338)          | (0.2338)               |
| PA \_t-1             | 0.3721 *        | XXXXX                         | 0.1332            | 0.1966                 |
|                       | (0.1733)        |                             |                   | (0.1527)               |
| L                     | -0.4193         | -0.5918 ***                   | 0.3406            | 0.1555                 |
|                       | (0.8373)        | (0.4914)                      | (0.1454)          | (0.1479)               |
| K                     | 0.0138          | 0.4481 **                     | 0.0038            | 0.0132                 |
|                       | (0.0873)        | (0.1762)                      | (0.1479)          | (0.1479)               |
| GS                    | 0.1559          | 0.1815                        | 1.1266 **         | 0.4901                 |
|                       | (0.9517)        | (0.1987)                      | (0.4023)          | (0.3067)               |
| R^2                   | 0.9397          | 0.9953                        | 0.9960            | 0.9970                 |
| Adjusted R^2          | 0.9457          | 0.9934                        | 0.9944            | 0.9958                 |
| P (F-statistic)       | 0.0000          |                               | 0.0000            |                       |

Note: Model 1 is about parameter estimations and tests based on the input and output data of foreign investment in R&D; Model 2 is about parameter estimations and tests based on input-output data of domestic enterprises. “*” means that the significance test was passed at the 0.05 level, “**” means that the significance test was passed at the 0.05 level, and “***” means that the significance test was passed at the 0.01 level. The numbers in brackets are standard errors. The F test value is less than 0.05, which means that the overall model passed the significance test.

Table 2. Variables and their proxies.

| Variable               | Proxy                           | Index | Description                                                                 |
|------------------------|---------------------------------|-------|-----------------------------------------------------------------------------|
| Innovation Outputs     | The Number of Invention Patents Granted | PA    | Invention patents granted to foreign-funded R&D institutions in China annually |
| Innovation Performance | Sales of New Products           | NS    | The proportion of the revenue from new products in total sale revenue        |
| Innovation Inputs      | R&D Self-Fund                   | SF    | The proportion of the R&D internal investment in total investment            |
|                        | R&D Persons                     | PS    | The number of personals who involve in R&D activities                        |
|                        | Government Subsidy              | GS    |                                                                             |
Self-correlation is tested by the Durbin’s H Test. The estimate is $\text{OLS} = 0.067$, which can be used to obtain the Durbin’s H Test value of $0.586$. There is a self-correlation phenomenon in the autoregressive model (6). After the test, it is corrected by standard errors.

From the parameter estimations and tests of Model 1, we have the following conclusions. Firstly, R&D personnel and own capital investment have a significant and positive impact on the innovation performance of foreign-funded R&D. The coefficients $\beta_0$ pass the significance test at 1% and 10% levels, respectively. $R^2$ and adjusted $R^2$ are greater than the value of 0.95 in the test of Model 1-1, which confirms its good fit. From the estimate of parameter $\lambda$, the impacts of the R&D personnel input lag on revenue from new product sales are 0.5918, 0.1307, and 0.0289, respectively. The overall elasticity factor of R&D personnel input is 0.7596. Similarly, an overall elasticity factor of 0.5752 can be estimated for the self-funded inputs. This means that the natural logarithm of revenue from new product sales will increase by 76% and 57.52%, while each additional unit for R&D personnel (natural logarithm) and self-owned funds (natural logarithm) will increase by 100%.

Secondly, R&D personnel investment has a significant and positive impact on foreign R&D innovation output. The influence coefficient $\beta_0$ on the number of invention patents granted passes the significance test at the level of 10%. Based on the method above, the impact factors for the distribution hysteresis of this variable can be calculated to be 0.8702, 0.3228, and 0.1205. The overall elasticity factor for R&D personnel inputs to patent output is 1.3859. That is, each additional unit of natural logarithm of the variables will contribute to an increase of 1.3859 units of invention patent granted.

Thirdly, the Coyle tests of Model 1-1 and Model 1-2 do not support the significant relationship between government subsidies and their distribution lag, and foreign R&D innovation performance, innovation output, and value creation of collaborative innovation in global supply chains. In the long term, foreign investment in R&D innovation and growth still depends on its internal factor investment and combination. Government subsidies do not exhibit a positive intervention effect.

According to the parameter estimation and test of Model 2, although the government subsidy does not help the new product sales revenue of domestic enterprises, it has a significant and positive impact on the innovation output. The parameter estimation and test of Model 2-1 does not pass the significant level test. Therefore, we can conclude that government subsidy, R&D personnel, and self-owned funds have insignificant impacts on the innovation performance of domestic companies. In Model 2-2, in the test of short-term and long-term effects of government subsidy, $\lambda = 0.1332$; the relatively small absolute value indicates that the strength of government subsidies affecting the number of invention patents granted will quickly decline with time. The influence coefficient for the current period is 1.1266, and the elasticity coefficients for the three phases are $\beta_1 = 0.1500$, $\beta_2 = 0.0200$, and $\beta_3 = 0.0027$, respectively. We also derive the long-term impact factor to be 1.2849.

The results of the tests above show that government subsidies have significant long-term effects on domestic innovation output. Finally, the parameter estimation and test of the time-series model with multiplier items also shows the indirect influence of the behavior of government-subsidized domestic enterprises on foreign-invested R&D.

3.2. Micro-Effects of Government Subsidy on Foreign-Invested R&D

3.2.1. Propensity Score Match (PSM)

Is the difference in innovation output and innovation performance of foreign-invested R&D due to government subsidy? To answer this question, it is necessary to divide the samples into two groups: an experimental group and a control group.

The experimental group consists of those who had received government subsidy ($D_i = 1$), and the control group consists of those who had not received government subsidy ($D_i = 0$). After grouping, there are 152 samples in the experimental group and 159 samples in the control group. Taking R&D personnel, R&D own capital investment, R&D cooperation
intensity, and patent protection index as covariates, and innovation output and innovation performance as outcome variables, the propensity score can be calculated. The PSM analysis is carried out with Stata 11.0, a statistical analysis software.

A logistic regression model is built to generate a probability value of the government subsidy of each sample, and a pscore is calculated accordingly. Then, the radius matching method is used to complete the match of samples. The average processing effect (ATT) and the control group average processing effect (ATE) values (as shown in Table 3) are calculated at the same time.

Table 3. PSM Average Processing Effect (ATT)-End variable based on the number of invention patents granted and new product sales revenue.

| Variables               | Samples   | Treatment | T-Test |
|-------------------------|-----------|-----------|--------|
| Innovation outputs      | Unmatched | ATT 20.9727 | −1.29  |
|                         |           | ATU 77.215 | −0.68  |
| Innovation performance  | Unmatched | ATT 7691.67 | 1.24   |
|                         |           | ATU 5241.90 | 0.48   |

Note: The radius matching method produces the average processing effect of the sample processing group, namely ATT, and the average processing effect of the sample control group, namely ATU.

Table 3 shows that the ATT and ATE values are 7691.67, 5241.90, 20.9727, and 77.215, respectively. After the matching, five samples in the experimental group failed to match with an appropriate control.

3.2.2. Balance Test

The assumption that the PSM satisfies equilibrium and common support needs to be tested. Among them, the PSM balance test, as shown in Table 4, demonstrates that all standard deviations of the remaining covariables, except the patent protection index, decrease. Their values are 3.2%, 0.8%, 3.2%, and 4.4%, respectively. They are all less than 5%. Therefore, we can conclude that the experimental group and the control group are balanced after the match which passes the equilibrium test. With the same covariable and using the number of invention patents granted as the outcome variable, the same conclusion can be drawn in the balance test. This confirms that outcome variable, covariable, and the radius matching method are reasonable.

Table 4. PSM balanced test and analysis with the number of invention patents granted as output variable.

| Variables | Unmatched/(Matched) | Average | (Bias%) | T-Test | V(F)/V(C) |
|-----------|---------------------|---------|---------|--------|-----------|
|           | Treatment  | Control  |
| L         | U        | 174.65   | 152.98  | 7.1    | 0.93      | 1.56      |
|           | M        | 150.53   | 140.88  | 3.2    | 0.38      | 1.36      |
| K         | U        | 2.3843   | 3.1718  | −78.2  | −9.97     | 0.95      |
|           | M        | 2.4023   | 2.3946  | 0.8    | 0.09      | 1.03      |
| CO        | U        | 2.7239   | 2.7852  | −5.6   | −0.71     | 0.99      |
|           | M        | 2.7305   | 2.6955  | 3.2    | 0.38      | 1.20      |
| PR        | U        | 4.2090   | 4.1909  | 2.8    | 0.35      | 0.83      |
|           | M        | 4.1953   | 4.1672  | 4.4    | 0.50      | 0.90      |

Note: “U” and “M” represent matched and unmatched, respectively. The assumed variables in the processing are continuous variables. A% bias deviation rate of less than 10% is a better match.

The density function reveals the sample matching effect further. The density functions before and after matching are shown in Figure 1. If new product sales revenue is used as the outcome variable, the sample distributions of the experimental group and control group are consistent. Moreover, Figure 2 illustrates the overall matching effect.
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(a) Density pscore before matching. (b) Density pscore after matching. Figure 1. Density pscore before and after matching with PA as output variable.

(a) Density pscore before matching. (b) Density pscore after matching. Figure 2. Density pscore before and after matching with NR as output variable.

In short, our results show that the main effect of governmental R&D subsidy for foreign enterprises is to enhance direct innovation output, while its main effect on domestic innovation is to promote innovation performance. Government R&D subsidy has become the main factor of internal differences between R&D innovation output and innovation performance of the R&D activities of foreign enterprises in China. Furthermore, the causal relationship between government R&D subsidy and innovation performance has also been supported.

4. Discussion

Based on the estimation and test of the distribution lag model, we can explain how government subsidies affect the innovation output and performance of foreign funded R&D under global supply chains as follows. From the view of capital factors, both R&D subsidy offered by the government and foreign capital investment in China can significantly increase the innovation output in China. In contrast, the innovation performance depends on the internal investment portfolio and growth to a large extent. The direct contribution of government subsidy as an “enhancer” to the innovation output is insignificant. However, the indirect role of its externality cannot be ruled out.

Domestic innovators receive government subsidies, which may lead to better innovation performance. The main reason is that government subsidy promotes R&D investment, which enhances the efficiency of R&D resource allocation and improves the output rate of innovation in turn. Internal investment and innovation ability, as internal factors driving
innovation growth and market capacity of foreign investment, are still dominant in China. The direct economic effect of R&D subsidy policy is pronounced. Moreover, R&D institutions supported by the government can significantly increase the sales revenue from new products and form market advantages.

5. Conclusions

In this paper, based on the macro data from 2000 to 2016, we examine the lag effect of government subsidies, R&D personnel investment, and self-owned capital investment on innovation output (represented by the number of invention patents granted) and innovation performance (represented by the sales revenue of new products) from the perspective of global supply chains using the Almon method. Our main findings are as follows.

First, the long-term effect of government R&D subsidy on foreign R&D innovation ability in global supply chains is significant. However, government R&D subsidy does not significantly promote the R&D performance of foreign-funded institutions. Moreover, the innovation performance of domestic enterprises is significantly affected by the short-term effects of government subsidies. Based on the adjustment effect test, the government’s capital subsidies for domestic enterprises moderate the relationship between the internal investment of external R&D institutions and their innovative performance and innovative output, showing significant conductivity. Although R&D subsidies for foreign R&D institutions are squeezed, due to the spillover and competition effects, R&D subsidies can also significantly enhance the innovation vitality of foreign-invested R&D in China.

Second, we expand our research to individual levels of foreign-invested R&D and collect panel data, from 2015–2017, about innovative investment, innovative output, and government subsidies for R&D in China. The impact of government R&D subsidies on individual innovation is tested using the PSM radius matching method. Furthermore, the stability test is carried out. The results show that the experimental and control groups satisfy the assumption of equilibrium and common support, and the average treatment effect of R&D subsidies is significant.

We can derive the following policy insights based on our empirical analyses and results. Firstly, the mechanism of sharing intellectual property rights should be improved further. According to the differences between foreign funded and domestic institutions of higher learning and enterprises, measures and guidance should be devised for sharing and transferring property rights. The procedures for handling disputes over the attribution of intellectual property rights should be standardized. The institutional environment in which foreign and domestic innovation entities participate on an equal footing to develop cooperative projects and resolve conflicts should be improved. Secondly, the management of R&D subsidies should be further refined. Financial subsidy standards and strategies for foreign funded R&D should be implemented, and foreign investors should be guided to establish multi-platform and multi-form alliances with domestic research institutes and enterprises, such as joint research centers and joint laboratories. Governments should place more emphasis on alliance or organizations engaging in basic research and key technology development. They should standardize strategies for fund allocation according to the characteristics of the R&D activities and incentivize R&D entities to collaborate.

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