Research Article

Impacts of the Weighted Deduction Policy for R&D Expenses on Innovation Additionality of Firms: Empirical Evidence from China

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Based on the data of 3894 companies disclosed in the 2014–2017 Small and Medium Enterprises (SME) Board and Growth Enterprise Market (GEM) Annual Reports, our research evaluates the impacts of the weighted deduction policy for research and development (R&D) expenses on innovation additionality in the "Propensity Score Matching" (PSM) approach, from the moderation perspective of marketization, market competition, and political connections. The empirical findings are as follows: (1) The weighted deduction policy for R&D expenses has a positive effect on the additionality of input and output. The policy has an "additionality effect" on invention patents and utility patents, but it is not significant on appearance patents. (2) Low degree of marketization and high degree of market competition have positive moderating effects on the additionality of input and output. (3) Political connections strengthen the incentive effect of the weighted deduction policy for R&D expenses on the additionality of input and output. From the perspective of additionality, our research results enrich the literature on studies of incentive effects of policy innovation and also provide empirical support for the adjustment of the weighted deduction policy for R&D expenses.

1. Introduction

The implementation of the innovation-driven strategy is inseparable from the support of fiscal and tax policies. Previous studies showed that expenditure policies, such as financial subsidies and government procurement, may distort the allocation of resources, thus leading to rent-seeking and ignoring substantive innovation. In particular, when financial subsidies are improperly implemented, for example, when the scope of subsidies is too wide or the total is too large, the policy effect will be changed from the level of regulating social and economic activities to the burden of inhibiting economic development [1–3]. As a tax preferential policy, the weighted deduction policy for R&D expenses has been continuously valued once it is launched. It has witnessed expanding application scope (Finance and Taxation [2013] No. 70), lowering the implementation threshold (Finance and Taxation [2015] No. 119), and increasing the percentage of additional deductions (Finance and Taxation [2017] No. 34, Finance and Taxation [2018] No. 99, etc.). In practice, in the government’s support for R&D of firms, scientific and technological innovation has been gradually enhanced.

Most literature on other countries’ firms argued that preferential tax policies have reduced innovation costs, increased the operating cash flow of firms, and promoted firms’ investment on innovation [4–8]. Some studies on Chinese firms also showed that preferential tax policies are conducive to the innovation investment of firms [9, 10]. Part of the research was based on changes in the weighted deduction policy for R&D expenses and found that the incentive effect of preferential treatment on R&D investment of firms is obvious [11–14]. Some studies analyzed preferential tax policies from the perspective of input, while few studies evaluated firm innovation output, and the conclusions are quite different. As has been demonstrated, the output of innovation and efficiency of firms have been significantly improved; the incentive effect of weighted deduction policy for R&D expenses is heterogeneously the result of firm ownership, firm scale, and whether it is a high-
tech enterprise [15]. On the output side, at the same time, the weighted deduction policy for R&D expenses only promotes the increase of the R&D output scale but has no significant impact on the output intensity, as demonstrated by the authors of [16]. Their research emphasized the verification of policy effects from the full perspective of the enterprise innovation chain.

Additionality effect and signal function are two frontier concepts that have gradually developed to reduce cognitive biases in evaluation. The “additionality” policy evaluation is based on scientific causal inference and has strong persuasive power. At present, most policy evaluations follow the additionality framework proposed by Georgiou, that is, the additionality changes in input, output, and behavior that government support brings to firms. The SME Board and GEM are important platforms to support the national independent innovation strategy. They provide institutional support for the innovation of small- and medium-sized firms and high-tech industries mainly by establishing the following mechanisms: the risk-sharing and profit-sharing financing mechanisms, equity incentive mechanisms, a survival-of-the-fittest mechanism for prior and subsequent screening, and so forth. With such a support, they may further enhance the function of the capital market to serve small- and medium-sized firms. Therefore, we introduce the additionality effect analysis framework and collect the annual report data of 3894 companies (2014–2017) on the SME Board and GEM to verify the incentive effect of weighted deduction policy for R&D expenses on innovation input and output. We also incorporate signal transmission and political connections into the analysis of the moderating effect of the additionality effect of innovation, by adopting the PSM approach to deal with endogeneity problems. At the end of the study, the empirical results support all hypotheses in this article except for H5b and H6b. The research design demonstrates the comprehensiveness of policy incentives, while research findings provide empirical basis for the improvement of the policy.

2. Theoretical Analysis and Hypothesis

2.1. Analysis of the Incentive Effect Mechanism of the Weighted Deduction Policy. Tax incentives are a common policy stimulus used by governments of various countries, and the weighted deduction policy for R&D expenses is considered the most inclusive and fair among them. The incentives of the policy to firms are realized through two transmission channels, which directly stimulate firms’ innovation investment and indirectly stimulate market support for firms [17]. Previous studies have proved that the weighted deduction policy for R&D expenses stimulates firms to further increase innovation input, thereby increasing innovation output. At the same time, Lerner found that the government’s science and technology plan conveys corporate innovation quality signals to venture investors and reduces information asymmetry [18]. Feldman proposed that government funding has a “halo effect,” which can send a quality signal to the market that companies have development potential [19]. The support of the government plays a role in signal transmission to a certain extent. It can guide the convergence of advantageous resources in the market, provide new resource support channels for firm’s innovation [20], induce firms to change their original behaviors, and further innovate in the original or new fields, thus increasing R&D investment [21]. In addition, as a government support policy, it also serves as a signal; that is, it can transmit information on the potential innovation quality of firms to the market, attract funds from external financing institutions, further ease financing constraints, increase R&D investment, and thereby increase firm’s innovation output. Accordingly, we propose Hypothesis 1 and Hypothesis 2.

H1: Keeping other factors unchanged, the deduction of R&D expenses can significantly improve additionality investment.

H2: Keeping other factors unchanged, the deduction of R&D expenses can significantly improve the output increment.

2.2. The Moderating Effect of Intermediary Factors on the Incentive Effect of Weighted Deduction Policy

2.2.1. Degree of Marketization. Areas with a high degree of marketization have a high level of market finance, broad corporate financing channels, and easy access to support from external financial institutions such as banks. The company has a better R&D environment or strong independent R&D motivation [22]; these advantages will greatly promote corporate innovation and improve political connections, thus producing the effect of ”better plus better.” For example, He Kang considered the impact of heterogeneous factors on the effect of the weighted deduction policy for R&D expenses and concluded that weighted deduction policy for R&D expenses has a better incentive effect on firm innovation in highly market-oriented regions. Some scholars hold different views. Yet, in regions with low marketization, financial markets and factor markets are not mature enough; companies have to face large financing constraints, high risks of intellectual property infringement, high levels of information asymmetry, and high costs for investors to screen companies. Those inferior situations have led to insufficient willingness to innovate, thus eventually reducing firm innovation [23]. However, at the same time, it can better reflect the incentive effect of policies on the innovation capabilities of firms. For example, Ren and Song used a sample of listed Chinese manufacturing companies to empirically test the hypothesis that the degree of marketization is low and the policy effect of R&D plus deduction is better [24].

In low-market areas, where the market is not well developed, the resources of firms must be obtained through informal channels, and government support is particularly important. For firms under low marketization, specifically, they have uneven good and bad, low technological innovation information circulation, and serious information asymmetry. Those characteristics have weakened the signals released by the firm. However, the government can transmit the potential positive information of the firm to the market
through supporting policies, which can increase the recognition of the firm by external institutions, reduce the screening cost of external investors, promote investment willingness, so as to promote the concentration of resources to firms enjoying preferential policies, and enhance the innovation power of firms [25]. Based on this, we make assumptions H3a and H3b.

H3a: Low marketization has a positive regulatory effect on the additionality effects of the weighted deduction policy for R&D expenses.

H3b: Low marketization has a positive regulatory effect on the additionality output effect of the weighted deduction policy for R&D expenses.

2.2.2. Market Competition. Market competition is a significant indicator in the external environment of a company. For different market competitions, firms have accordingly adopted survival strategies. For example, in the fierce market competition, in order to avoid being screened out by the "survival-of-the-fittest" mechanism, companies are willing to disclose more information about their own operations, management, innovation, and so forth and transmit "market signals" to external resource exchanges to get a pool of resources [26]. However, this signal is just a single one, and the evaluation of innovation capability cannot be directly presented through financial data, nor can it rely solely on the evaluation of third-party institutions. In addition, China’s market development has not yet been fully matured, with the government still playing an important role in market management, and companies need to send more valuable signals to achieve resource acquisition [27]. Through the layer-by-layer screening of firms that have received government resource support, the support policy can transmit signals of the firm’s potential innovation capabilities, which can help firms obtain more market support and promote firm innovation. Wu et al. found that the increased market competition can significantly stimulate the incentive effect of preferential tax policies on R&D investment [28]. In a low market competition environment, as the firm’s market share stays relatively stable, the firm holds a low innovation willingness for future survival and development. Conversely, it prefers to maintain its monopoly position, so it sends signals with the motivation of obtaining resources for an expanded scale. With such "signals," though, it is still difficult for the firm to perform well in promoting innovation [29]. Accordingly, this article assumes H4a and H4b.

H4a: High market competition has a positive regulatory effect on the additionality effect of the weighted deduction policy for R&D expenses.

H4b: High market competition has a positive regulatory effect on the additionality output effect of the weighted deduction policy for R&D expenses.

2.2.3. Political Connections. From the perspective of signal transmission, political connections exert a certain signal function. It can release information that companies have scarce resources and good reputation and improve the continuity and stability of the company’s external resource acquisition, so as to increase R&D investment, thus promoting innovation [30]. Here, we have to notice that, as relatively abstract "relationship resource," political connections have just sent unclear signals. They have been regarded, on the contrary, more as a means for the government to regulate resources than as the "signal-sender" as mentioned above. The weighted deduction policy for R&D expenses is one of the carriers for the government to reduce taxes and pass on resources to support firm innovation. Such a policy, whether to be applied or not, can be an objective indicator to measure whether a company has scarce resources. At the same time, the policy itself has the signal function of certifying quality. For firms that have undergone strict rules "selection," they have shown the characteristics of high-quality innovation in the way of sending a double-guarantee-signal to investors in the market. In addition, in the view of political leadership, investors take into consideration not only the resources and innovation quality owned by firms but also the guiding role of politics. When firms are highly politically connected, their relationship resources can reduce the information asymmetry between government and themselves. Once they have enjoyed government preferential policies, firms will have a clearer understanding of policy procedures and policy connotations, and it is easier to identify policy utilization points, so as to send a signal to the market to comply with the political orientation, attract external investment, and increase investment in innovation, thus promoting firm innovation [31]. At the same time, however, this factor may also have a negative effect on corporate innovation. Some scholars pointed out that maintaining political connections requires companies to spend a lot of time, capital, and labor costs, as well as some hidden costs. In that way, companies spend more management expenses, erode R&D investment, and ultimately lead to a decline in corporate innovation and performance [32]. Therefore, political connection cost may offset the effect of signal transmission and weaken the effect of policy incentives. Based on that, this article makes exploratory research:

H5a: Political connections have a positive regulatory effect on the additionality investment of the weighted deduction policy for R&D expenses.

H5b: Political connections have a negative regulatory effect on the additionality investment of the weighted deduction policy for R&D expenses.

H6a: Political connections have a positive regulatory effect on the output increment of the weighted deduction policy for R&D expenses.

H6b: Political connections have a negative moderating effect on the output increment of the weighted deduction policy for R&D expenses.

3. Research Design

3.1. Sample and Data Selection. The empirical objects are listed firms on the SME Board and GEM. The sample data come from the CSMAR database, the official website of the State Intellectual Property Office, and cninfo.com. The time span is from 2014 to 2017. Afterwards, this research
determines 1601 valid samples of the “processing group”; they are firms that enjoy the policy of deduction for R&D expenses. Among those samples, 2293 are identified as effective ones of the “control group.” They are firms without the endowment of the policy of deduction for R&D expenses. See Table 1 for details. Data processing in this article includes the following: (1) The financial industry and industries that are not covered by the policy are deleted. (2) ST, PT, and delisted companies are eliminated. (3) Companies with missing key variables and abnormal financial indicators are eliminated. Data processing is completed by Stata15.

3.2. Variable Selection

3.2.1. The Explained Variable

Additionality Investment. After applying PSM, the ATT value is the R&D investment of the firms that enjoy the policy (processing group) minus the R&D investment of the firms that do not enjoy the policy (control group). With reference to Feng et al. [33], we use the logarithm of the absolute value of R&D investment to measure R&D investment.

Increase in Output. After applying PSM, the ATT value is the patent output of the firms enjoying the policy (processing group) minus the patent output of the firms not enjoying the policy (control group). Based on the availability, verifiability, and reality of data, researchers mostly use the number of patent applications as an indicator to measure innovation output. We further subdivide patents into invention patents, utility patents, and appearance patents.

3.2.2. Explaining Variables. The explanatory variable we selected is whether the company enjoys the weighted deduction policy for R&D expenses. This variable is presented in the form of a dummy variable. The firm that enjoys the weighted deduction policy for R&D expenses is the treatment group, which is recorded as enjoy1 = 1, and the firm that does not enjoy the weighted deduction policy for R&D expenses, only with the support from the policy, is the control group, which is recorded as enjoy1 = 0.

3.2.3. Control Variables. Firm scale, firm growth, capital intensity, current debt ratio, asset-liability ratio, intangible assets, technical assets, marketization degree, market competition, political connection, equity concentration, equity checks and balances, degree of separation of two powers, time, and region are used as control variables for propensity score matching. The specific variables are shown in Table 2.

3.2.4. Covariate. In order to better estimate the covariates that can significantly distinguish the treatment group from the control group, we establish a logit model, introduce the control variables that were initially screened into the model, and select the covariates according to the significance to introduce the PSM model to establish the final model. After calculation, the variables in Table 3 are selected.

3.3. Propensity Score Matching Method. After a policy is implemented, we intend to evaluate the policy to obtain its implementation effect. Essentially, we attempt to answer the following question: What will happen if the policy is not implemented? At the same time, the preferential policy needs to comply with certain conditions, and it is the firm that makes the decision whether to adopt it or not. This shows that the firm does not enjoy the policy randomly. The firm that can enjoy the policy may have higher R&D expenditure and innovation output, which makes the adoption of the traditional multiple regression estimation of the system. It will produce systematic bias and overestimate the incentive effect brought by the policy. In order to overcome the two problems above, PSM can be used to isolate a cleaner policy effect.

The specific research steps are as follows: First, use processing variable grouping. This paper uses whether to enjoy the policy as the basis for grouping. Second, find matching variables. Third, construct a logit model and obtain specific covariates. Test whether the basic assumptions are met. Fourth, estimate the propensity score value and perform matching. In order to make the research results more stable, this paper adopts four methods: one-to-one matching, nearest neighbor matching, radius matching, and kernel matching [34].

\[
P_{S1} = P(x_i)
= Pr(D_i = 1 \mid x_i) = \frac{exp(\beta x_i)}{1 + exp(\beta x_i)} \tag{1}
\]

Fifth, calculate the ATT value:

\[
ATT = E_{P(x_i)\mid D=1}[E(P_{S1} - P_{S0}) \mid D = 1, P(x_i)]
= E_{P(x_i)\mid D=1}[E(P_{S1}) \mid D = 1, P(x_i) - E(P_{S0}) \mid D = 1, P(x_i)]. \tag{2}
\]

4. Empirical Results and Analysis

4.1. Descriptive Statistical Analysis. It can be seen from the research results that the average R&D investment of the treatment group is 8.62, the median is 8.57, the minimum value is 5.51, and the maximum value is 12.67, while the control group’s values are 8.50, 8.51, 2.67, and 12.04, respectively. The overall value of the R&D investment of the treatment group is higher than that of the control group,
Table 2: Variable description table.

| Variable          | Variable symbol | Variable name             | Measure                                                                 |
|-------------------|-----------------|---------------------------|-------------------------------------------------------------------------|
| Dependent variable| Inputd4i         | R&D investment            | Logarithm of absolute value of R&D investment (control group-treatment group) is the ATT value |
| Output additionality| Invent_all1      | Patent output             | The absolute value of the number of patent applications (same as above)   |
|                    | Invent1          | Patent                    | The absolute value of the number of invention patent applications (same as above) |
|                    | Utility1         | Utility patent            | The absolute value of the number of utility patent applications (same as above) |
|                    | Face1            | Appearance patent         | The absolute value of the number of appearance patent applications (same as above) |
| Core variables    | Enjoy1           | Whether to enjoy the deduction policy for R&D expenses | Enjoy the policy as enjoy1 = 1 and not enjoy the policy as enjoy1 = 0 |
| Control variable  | Size1            | Firm size                 | Logarithm of total assets plus 1                                       |
|                    | Grow             | Corporate growth          | Current operating income-last operating income/last operating income     |
|                    | Capdensity       | Capital intensity         | Fixed assets/total assets                                               |
|                    | Capdensity1      | Capital intensity 1       | Total assets/employee pairs                                             |
|                    | Shortd           | Current debt ratio        | Current liabilities/total assets                                         |
|                    | Fuzhaiper        | Assets and liabilities    | Total liabilities/total assets                                           |
|                    | Wuxingcap        | Intangible assets         | Total intangible assets                                                 |
|                    | Tec              | Technical assets          | Intangible assets/total assets                                          |
|                    | Marketdex        | Marketization             | Use Fan Gang and Wang Xiaolu to calculate data                          |
|                    | Compete          | Market competition        | Sales expenses/operating income                                         |
|                    | Politic          | Political connection      | It is assigned a value of 1 if it is politically connected and a value of 0 if it is not politically connected |
|                    | Shrcr1           | Equity concentration      | The largest shareholder’s shareholding ratio                             |
|                    | Shrcr5           | Equity checks and balances| Shareholding ratio of the top two largest shareholders/sharholding ratio of the top five largest shareholders |
|                    | Shrcr7           | Equity checks and balances1| The largest shareholder’s shareholding ratio/the top five largest shareholder’s shareholding ratio |
|                    | Separation       | Separation of two rights  | Difference between control rights and management rights                 |
|                    | Time             | Time dummy                | The value of the year before 2016 is 0, and the value of the year of 2016 and after is 1 |
|                    | Area             | Regional dummy variable   | Set three dummy variables according to the east, middle, and west        |
|                    | Sic_men          | Industry dummy variables  | Excluding industries that do not enjoy the policy, set up according to the classification of national economic industries |

Table 3: Variable screening table.

| Variable                        | Estimated coefficient | Standard error | z      | p     |
|---------------------------------|-----------------------|----------------|--------|-------|
| Technical assets                | −7.20                 | 1.82           | −3.95  | 0.001 |
| Current debt ratio              | −0.81                 | 0.30           | −2.68  | 0.01  |
| Intangible assets               | 0.28                  | 0.08           | 3.60   | 0.001 |
| Asset intensity                 | −1.24                 | 0.36           | −3.42  | 0.001 |
| Equity checks and balances      | 0.18                  | 0.07           | 2.74   | 0.01  |
| Marketization                   | 0.22                  | 0.03           | 7.52   | 0.001 |
| Firm size                       | −0.42                 | 0.09           | −4.46  | 0.001 |
| Separation of two Rights        | 0.02                  | 0.01           | 2.01   | 0.01  |
| Time                            | 0.27                  | 0.09           | 3.03   | 0.001 |
| Technology Service industry     | 1.49                  | 0.48           | 3.08   | 0.001 |
| Manufacturing                   | 1.39                  | 0.28           | 4.94   | 0.001 |
| Public administration           | 1.57                  | 0.41           | 3.88   | 0.001 |
| Information software industry   | 1.35                  | 0.30           | 4.46   | 0.001 |
| Construction industry           | 0.91                  | 0.39           | 2.30   | 0.02  |
indicating that the R&D investment of the treatment group is much greater than that of the control group. From the perspective of the total number of patent applications, the mean value of the treatment group is 2.32 and the median is 2.40. Compared with 2.12 and 2.20 of the control group, the overall output level of the treatment group is also higher than that of the control group. Observing each detailed patent output index, we can still find this conclusion. Although some indicators of the control group are slightly higher compared to the treatment group at the maximum value, the values in each percentile are still significantly higher in the treatment group. Therefore, it still shows that the overall output of the treatment group is higher than that of the control group. This also shows to a certain extent that the level of innovation ability of the treatment group is relatively small, while the level of innovation ability of the control group may be uneven, with a large gap between each other. Preliminary inference is as follows: the companies that enjoy the weighted deduction policy for R&D expenses do perform better in terms of input and output, but is this outstanding performance the effect of policy incentives or the company itself has such characteristics? The use of PSM can reduce endogeneity problems and help us better identify policy effects. The details are shown in Table 4.

4.2. Hypothesis Testing. The common support hypothesis is to require a large degree of overlap between the control group and the treatment group to ensure that every individual in the treated group can find at least one similar individual in the control group. Figures 1 and 2 show the results before and after matching.

The scores of the prematching treatment group are concentrated in [0.1, 0.71], the propensity scores of the control group are concentrated in [0.02, 0.73], and the overlapping area of the two sides is [0.1, 0.71]. After applying PSM, the overlapping areas of the two sides are further expanded, with the two curves fitting more closely. It shows that the characteristics of the treatment group and the control group are very close, which indicates that PSM solves the problem of sample endogeneity better. It also provides a clearer reflection of the policy incentive effect.

4.3. The Average Incentive Effect of the Sample Population. The results show that, after eliminating individual differences, that is, after controlling for factors other than policy factors, the R&D investment and patent output of the treatment group are significantly higher than those of the control group at the level of 5%. It indicates that the weighted deduction policy for R&D expenses has an impact on the investment. The output has a significant role in promoting. Assume that H1 and H2 are verified.

From the perspective of output breakdown, after matching, the difference in ATT between the treatment group and the control group on invention patents and utility patents is significant at least at the level of 10%, indicating that the policy has an "additionality effect" on invention patents and utility patents, which generates additional research and development. Appearance patents do not show significance, indicating that the policy has not brought about the creation of additionality appearance patents. In general, the policy has strengthened the incentives for additionality input and additionality output. Or at least it shows that, under the effect of signal transmission, the policy has transmitted information on the quality of firm innovation to the outside, helped firms to obtain external recognition and financial support, and promoted the creation of additionality innovation input and output. The details are shown in Table 5.

4.4. Policy Incentive Effect under the Adjustment of Intermediary Factors

4.4.1. The Role of Marketization. The results show that, under the low degree of marketization, the policy exerts a corresponding incentive effect. This effect is confirmed under neighbor matching, radius matching, and core matching, indicating that the conclusion is stable. Specifically, (1) in terms of R&D investment, under low marketization, after R&D investment is matched, the ATT difference is still highly significant at the 1% level under neighbor matching, radius matching, and nuclear matching, which shows that the policy supplements the R&D investment of firms; (2) in terms of patent output, the ATT difference of patent output was reduced to a significance level of 5% after matching, which has still steadily proved the positive effect of the policy; after further exploring the patent output under segmentation, we can also find that the matched control group and treatment group still have high significance at the 5% level in utility patents and invention patents, while appearance patents have significant differences at least at the 10% level. Such findings have further confirmed the incentive effect of the policy, assuming that H3a and H3b are verified. See Table 6 for details.

4.4.2. The Role of Market Competition. The results show that the weighted deduction policy for R&D expenses exerts an incentive effect under high market competition. This incentive effect is consistent and significant under neighbor matching, radius matching, and nuclear matching, which proves that the conclusion is reliable. From the perspective of R&D investment, under high market competition, before and after matching, the ATT of the treatment group and that of the control group are both significant at the level of 1% or 5%, which shows that, under high market competition, companies that enjoy the policy have higher R&D investment. This indicator is still significant after eliminating individual differences, which proves the existence of policy incentives. From the perspective of patent output, under high market competition, after matching, the ATT value of the treatment group and that of the control group are significant at the 10% level, which shows that the policy has produced a positive effect; with a further observation of the detailed output indicators, after matching, the ATT value of the invention patent is significant under one-to-one matching, radius matching, and nuclear matching, while the ATT values of utility patents are all significant in four
matching methods, while the appearance patents are not significant before and after the matching in different matching methods. This has proved the incentive effect of policies on innovation output, and it has also shown that policies do not have an incentive effect on nontechnical innovation. Assuming that H4a and H4b are verified, see Table 7 for details.

4.4.3. The Role of Political Connections. The results show that politically connected companies are more likely to receive policy incentives. This incentive is significant in the four matching methods, which proves the credibility of the conclusions. Specifically, (1) at the level of R&D investment, the difference between the postmatching treatment group and the control group of politically connected companies still exists at a significance level of 1%, and the difference value ATT has increased to a certain extent, which shows that the policy has exerted a positive effect in the politically connected group; (2) at the level of patent output, politically connected firms, after matching, ATT shows a difference at a significance level of 5%, indicating that the policy has played an incentive role; (3) from the perspective of patent subdivision, it can be seen that the difference in ATT value after the matching of invention patents and utility patents still exists, while appearance patents become insignificant. This shows that the policy has a positive effect on the improvement of the quality of firm innovation. Assuming that H5a and H6a have been verified (see Table 8).

4.5. Robustness Test. We try to use spline matching to test the full sample. The robustness test results show that the weighted deduction policy for R&D expenses stimulates the increase in input and output. Specifically, (1) in terms of R&D investment, after eliminating the interference of non-policy-influencing factors, the difference between the treatment group and the control group is still highly significant at the level of 1%, which proves that the weighted deduction policy for R&D expenses has a positive effect on
Table 5: The average treatment effect of the sample population.

| Variable   | Match       | Control group | Treatment group | ATT   | S.E. | T-state |
|------------|-------------|---------------|-----------------|-------|------|---------|
|            | Before      | 2.32          | 2.13            | 0.19  | 0.05 | 3.98*** |
|            | After       | 2.32          | 2.18            | 0.14  | 0.06 | 2.14**  |
| One-to-one matching |             |               |                 |       |      |         |
|            | After       | 8.62          | 8.50            | 0.12  | 0.03 | 3.64*** |
|            | Before      | 8.62          | 8.51            | 0.11  | 0.05 | 2.42**  |
|            | After       | 1.61          | 1.47            | 0.14  | 0.04 | 3.53*** |
|            | Before      | 1.61          | 1.50            | 0.11  | 0.06 | 1.91*   |
|            | After       | 1.52          | 1.36            | 0.16  | 0.04 | 3.62**  |
|            | Before      | 1.52          | 1.40            | 0.12  | 0.06 | 1.99**  |
|            | After       | 0.55          | 0.45            | 0.10  | 0.03 | 3.12*** |
|            | After       | 0.55          | 0.48            | 0.06  | 0.04 | 1.46    |
| Nearest neighbor matching |             |               |                 |       |      |         |
|            | Before      | 2.32          | 2.13            | 0.19  | 0.05 | 3.98*** |
|            | After       | 2.32          | 2.21            | 0.11  | 0.06 | 1.96**  |
|            | Before after| 8.62          | 8.50            | 0.12  | 0.03 | 3.64*** |
|            | After       | 8.62          | 8.53            | 0.10  | 0.04 | 2.44**  |
|            | Before      | 1.61          | 1.47            | 0.14  | 0.04 | 3.53*** |
|            | After       | 1.61          | 1.53            | 0.09  | 0.05 | 1.79    |
|            | Before      | 1.52          | 1.36            | 0.16  | 0.04 | 3.62**  |
|            | After       | 1.52          | 1.40            | 0.12  | 0.05 | 2.35**  |
|            | Before      | 0.55          | 0.45            | 0.10  | 0.03 | 3.12*** |
|            | After       | 0.55          | 0.53            | 0.02  | 0.04 | 0.51    |
| Radius matching |             |               |                 |       |      |         |
|            | Before      | 2.32          | 2.13            | 0.19  | 0.05 | 3.98*** |
|            | After       | 2.32          | 2.21            | 0.11  | 0.06 | 1.96**  |
|            | Before after| 8.62          | 8.50            | 0.12  | 0.03 | 3.64*** |
|            | After       | 8.62          | 8.53            | 0.10  | 0.04 | 2.44**  |
|            | Before      | 1.61          | 1.47            | 0.14  | 0.04 | 3.53*** |
|            | After       | 1.61          | 1.53            | 0.09  | 0.05 | 1.79    |
|            | Before      | 1.52          | 1.36            | 0.16  | 0.04 | 3.62**  |
|            | After       | 1.52          | 1.40            | 0.12  | 0.05 | 2.35**  |
|            | Before      | 0.55          | 0.45            | 0.10  | 0.03 | 3.12*** |
|            | After       | 0.55          | 0.53            | 0.02  | 0.04 | 0.51    |
| Nuclear matching |             |               |                 |       |      |         |
|            | Before      | 2.32          | 2.13            | 0.19  | 0.05 | 3.98*** |
|            | After       | 2.32          | 2.19            | 0.13  | 0.05 | 2.56**  |
|            | Before      | 8.62          | 8.50            | 0.12  | 0.03 | 3.64*** |
|            | After       | 8.62          | 8.54            | 0.09  | 0.04 | 2.47**  |
|            | Before      | 1.61          | 1.47            | 0.14  | 0.04 | 3.53*** |
|            | After       | 1.61          | 1.52            | 0.09  | 0.04 | 2.2**   |
|            | Before      | 1.52          | 1.36            | 0.16  | 0.04 | 3.62**  |
|            | After       | 1.52          | 1.38            | 0.14  | 0.05 | 3.03**  |
|            | Before      | 0.55          | 0.45            | 0.10  | 0.03 | 3.12*** |
|            | After       | 0.55          | 0.51            | 0.04  | 0.03 | 1.23    |

Table 6: Policy incentive effects under different degrees of marketization.

| Variable   | Match | High marketization | Low marketization | Treat | ATT | T | Treat | ATT | T |
|------------|-------|---------------------|--------------------|-------|-----|--|-------|-----|--|
|            | Control |          |          |       |     | | Control |          |     | |
| One-to-one matching |         |           |         |       |     | |           |         |     | |
| Output     | Before  | 2.34     | 2.32    | 0.11  | 1.69* | 2.28 | 2.06 | 0.23 | 3.43*** |
|            | After   | 2.34     | 2.29    | 0.06  | 0.61 | 2.28 | 2.16 | 0.12 | 1.37 |
| Investment | Before  | 8.71     | 8.68    | 0.03  | 0.65 | 8.51 | 8.36 | 0.15 | 2.87*** |
|            | After   | 8.71     | 8.64    | 0.07  | 0.66 | 8.51 | 8.42 | 0.09 | 1.29 |
| Invest     | Before  | 1.62     | 1.53    | 0.09  | 1.53 | 1.60 | 1.42 | 0.18 | 3.11*** |
|            | After   | 1.62     | 1.56    | 0.06  | 0.74 | 1.60 | 1.51 | 0.09 | 1.09 |
| Utility    | Before  | 1.55     | 1.43    | 0.13  | 2.02**| 1.47 | 1.31 | 0.16 | 2.6** |
|            | After   | 1.55     | 1.41    | 0.14  | 1.58 | 1.47 | 1.35 | 0.12 | 1.43 |
| Appearance | Before  | 0.62     | 0.56    | 0.06  | 1.11 | 0.45 | 0.36 | 0.09 | 2.29***|
|            | After   | 0.62     | 0.67    | −0.06 | −0.81| 0.45 | 0.36 | 0.09 | 1.71 |
Table 6: Continued.

| Variable Match | High marketization | Low marketization |
|----------------|--------------------|-------------------|
|                | Control | Treat | ATT | T  | Control | Treat | ATT | T  |
| Nearest neighbor matching | Output | Before | 2.34 | 2.23 | 0.11 | 1.69 | ** | 2.28 | 2.06 | 0.23 | 3.43*** |
|                        | After   | 2.34  | 2.29 | 0.05 | 0.63 | 2.28 | 2.11 | 0.18 | 2.36** |
|                        | Investment | Before | 8.71 | 8.68 | 0.03 | 0.65 | 8.51 | 8.36 | 0.15 | 2.87*** |
|                        | After   | 8.71  | 8.63 | 0.08 | 1.51 | 8.51 | 8.37 | 0.14 | 2.58** |
|                        | Invest  | Before | 1.61 | 1.53 | 0.09 | 1.53 | 1.60 | 1.42 | 0.18 | 3.11*** |
|                        | After   | 1.62  | 1.55 | 0.07 | 1.07 | 1.60 | 1.47 | 0.13 | 1.99** |
|                        | Utility | Before | 1.55 | 1.43 | 0.13 | 2.02** | 1.47 | 1.31 | 0.16 | 2.6** |
|                        | After   | 1.55  | 1.47 | 0.08 | 1.11 | 1.47 | 1.31 | 0.16 | 2.31*** |
|                        | Appearance | Before | 0.62 | 0.56 | 0.06 | 1.11 | 0.45 | 0.36 | 0.09 | 2.29** |
|                        | After   | 0.62  | 0.66 | 0.04 | 0.76 | 0.45 | 0.35 | 0.10 | 2.21** |
| Radius matching | Output | Before | 2.34 | 2.23 | 0.11 | 1.69 | ** | 2.28 | 2.06 | 0.23 | 3.43*** |
|                        | After   | 2.34  | 2.29 | 0.05 | 0.62 | 2.29 | 2.10 | 0.19 | 2.55** |
|                        | Investment | Before | 8.71 | 8.68 | 0.03 | 0.65 | 8.51 | 8.36 | 0.15 | 2.87*** |
|                        | After   | 8.71  | 8.63 | 0.08 | 1.50 | 8.51 | 8.36 | 0.15 | 2.7** |
|                        | Invest  | Before | 1.62 | 1.53 | 0.09 | 1.53 | 1.60 | 1.42 | 0.18 | 3.11*** |
|                        | After   | 1.62  | 1.55 | 0.07 | 1.06 | 1.61 | 1.46 | 0.15 | 2.18** |
|                        | Utility | Before | 1.55 | 1.43 | 0.13 | 2.02** | 1.47 | 1.31 | 0.16 | 2.6** |
|                        | After   | 1.55  | 1.47 | 0.08 | 1.10 | 1.48 | 1.30 | 0.17 | 2.43** |
|                        | Appearance | Before | 0.62 | 0.56 | 0.06 | 1.11 | 0.45 | 0.36 | 0.09 | 2.29** |
|                        | After   | 0.62  | 0.66 | 0.04 | 0.77 | 0.46 | 0.35 | 0.11 | 2.32** |
| Nuclear matching | Output | Before | 2.34 | 2.23 | 0.11 | 1.69 | ** | 2.28 | 2.06 | 0.23 | 3.43*** |
|                        | After   | 2.34  | 2.29 | 0.05 | 0.77 | 2.28 | 2.11 | 0.18 | 2.63** |
|                        | Investment | Before | 8.71 | 8.68 | 0.03 | 0.65 | 8.51 | 8.36 | 0.15 | 2.87*** |
|                        | After   | 8.71  | 8.63 | 0.08 | 1.50 | 8.51 | 8.36 | 0.15 | 2.7** |
|                        | Invest  | Before | 1.62 | 1.53 | 0.09 | 1.53 | 1.60 | 1.42 | 0.18 | 3.11*** |
|                        | After   | 1.62  | 1.56 | 0.06 | 1.01 | 1.60 | 1.47 | 0.14 | 2.26** |
|                        | Utility | Before | 1.55 | 1.43 | 0.13 | 2.02** | 1.47 | 1.31 | 0.16 | 2.6** |
|                        | After   | 1.55  | 1.46 | 0.09 | 1.35 | 1.47 | 1.31 | 0.16 | 2.5** |
|                        | Appearance | Before | 0.62 | 0.56 | 0.06 | 1.11 | 0.45 | 0.36 | 0.09 | 2.29** |
|                        | After   | 0.62  | 0.63 | 0.01 | 0.22 | 0.45 | 0.38 | 0.07 | 1.67** |

Table 7: Policy incentive effects under different market competition levels.

| Variable Match | High competition | Low competition |
|----------------|------------------|----------------|
|                | Control | Treat | ATT | T  | Control | Treat | ATT | T  |
| Output | Before | 2.37 | 2.20 | 0.17 | 2.53** | 2.26 | 2.06 | 0.19 | 2.95*** |
| After   | 2.37  | 2.23 | 0.14 | 1.54 | 2.26 | 2.21 | 0.04 | 0.48 |
| Investment | Before | 8.58 | 8.46 | 0.12 | 2.59*** | 8.67 | 8.54 | 0.14 | 2.69*** |
| After   | 8.58  | 8.45 | 0.12 | 2.02** | 8.67 | 8.67 | 0.00 | 0.05 |
| Invest  | Before | 1.65 | 1.52 | 0.13 | 3.22** | 1.57 | 1.42 | 0.15 | 2.55** |
| After   | 1.65  | 1.50 | 0.15 | 1.87** | 1.57 | 1.56 | 0.01 | 0.06 |
| Utility | Before | 1.50 | 1.29 | 0.21 | 3.4** | 1.54 | 1.43 | 0.11 | 1.80 |
| After   | 1.50  | 1.35 | 0.15 | 1.77* | 1.54 | 1.47 | 0.06 | 0.73 |
| Appearance | Before | 0.70 | 0.67 | 0.03 | 0.63 | 0.38 | 0.24 | 0.14 | 3.96*** |
| After   | 0.70  | 0.71 | 0.01 | 0.08 | 0.38 | 0.29 | 0.09 | 1.66* |
| One-to-one matching | Output | Before | 2.37 | 2.20 | 0.17 | 2.53** | 2.26 | 2.06 | 0.19 | 2.95*** |
| After   | 2.37  | 2.22 | 0.15 | 1.92* | 2.26 | 2.21 | 0.12 | 1.49 |
| Investment | Before | 8.58 | 8.46 | 0.12 | 2.59*** | 8.67 | 8.54 | 0.14 | 2.69*** |
| After   | 8.58  | 8.46 | 0.12 | 2.3** | 8.67 | 8.60 | 0.07 | 1.32 |
| Invest  | Before | 1.65 | 1.52 | 0.13 | 3.22** | 1.57 | 1.42 | 0.15 | 2.55** |
| After   | 1.65  | 1.53 | 0.12 | 1.83* | 1.57 | 1.50 | 0.07 | 1.04 |
| Utility | Before | 1.50 | 1.29 | 0.21 | 3.4** | 1.54 | 1.43 | 0.11 | 1.80 |
| After   | 1.50  | 1.30 | 0.20 | 2.75*** | 1.54 | 1.44 | 0.09 | 0.28 |
| Appearance | Before | 0.70 | 0.67 | 0.03 | 0.63 | 0.38 | 0.24 | 0.14 | 3.96*** |
| After   | 0.70  | 0.70 | 0.00 | 0.07 | 0.38 | 0.29 | 0.09 | 2.12** |
### Table 7: Continued.

| Variable | Match | High competition | | | | Low competition | | |
|-----------|-------|------------------|---|---|---|------------------|---|---|
|           |       | Control | Treat | ATT | T   | Control | Treat | ATT | T   |
| Radius matching | | | | | | | | | |
| Output | Before | 2.37 | 2.20 | 0.17 | 2.53** | 2.26 | 2.06 | 0.19 | 2.95*** |
| | After | 2.37 | 2.22 | 0.15 | 1.93* | 2.26 | 2.14 | 0.12 | 1.47 |
| Investment | Before | 8.58 | 8.46 | 0.12 | 2.59*** | 8.67 | 8.54 | 0.14 | 2.69*** |
| | After | 8.58 | 8.46 | 0.12 | 2.31** | 8.67 | 8.60 | 0.07 | 1.27 |
| Invest | Before | 1.65 | 1.52 | 0.13 | 2.32** | 1.57 | 1.42 | 0.15 | 2.55** |
| | After | 1.65 | 1.53 | 0.12 | 1.83* | 1.57 | 1.50 | 0.07 | 1.02 |
| Utility | Before | 1.50 | 1.29 | 0.21 | 3.41** | 1.54 | 1.43 | 0.11 | 1.8* |
| | After | 1.50 | 1.30 | 0.20 | 2.75*** | 1.54 | 1.45 | 0.09 | 1.27 |
| Appearance | Before | 0.70 | 0.67 | 0.03 | 0.63 | 0.38 | 0.24 | 0.14 | 3.96*** |
| | After | 0.70 | 0.70 | 0.00 | 0.07 | 0.38 | 0.29 | 0.09 | 2.12** |

### Table 8: Policy incentive effects under different political connections.

| Variable | Mat | Politically connected | | | | No political connection | | |
|-----------|-----|-----------------------|---|---|---|------------------------|---|---|
|           |     | Control | Treatment | ATT | T   | Control | treatment | ATT | T   |
| Nuclear matching | | | | | | | | | |
| Output | Before | 2.33 | 2.11 | 0.22 | 3.44*** | 2.31 | 2.16 | 0.15 | 2.14** |
| | After | 2.33 | 2.11 | 0.21 | 2.36** | 2.31 | 2.24 | 0.06 | 0.65 |
| Investment | Before | 8.55 | 8.44 | 0.11 | 2.34** | 8.71 | 8.57 | 0.14 | 2.78*** |
| | After | 8.55 | 8.33 | 0.21 | 3.41*** | 8.71 | 8.63 | 0.09 | 1.29 |
| Invest | Before | 1.61 | 1.42 | 0.19 | 3.42** | 1.61 | 1.52 | 0.09 | 1.50 |
| | After | 1.61 | 1.40 | 0.22 | 2.82*** | 1.61 | 1.60 | 0.01 | 0.10 |
| Utility | Before | 1.55 | 1.34 | 0.21 | 3.56*** | 1.48 | 1.39 | 0.10 | 1.51 |
| | After | 1.55 | 1.37 | 0.17 | 2.06** | 1.48 | 1.35 | 0.13 | 1.43 |
| Appearance | Before | 0.59 | 0.48 | 0.11 | 2.31** | 0.51 | 0.41 | 0.10 | 2.14 |
| | After | 0.59 | 0.48 | 0.10 | 1.54 | 0.51 | 0.50 | 0.01 | 0.14 |
| Nearest neighbor matching | | | | | | | | | |
| Output | Before | 2.33 | 2.11 | 0.22 | 3.44*** | 2.31 | 2.16 | 0.15 | 2.14** |
| | After | 2.33 | 2.13 | 0.20 | 2.59*** | 2.31 | 2.22 | 0.09 | 1.06 |
| Investment | Before | 8.55 | 8.44 | 0.11 | 2.34** | 8.71 | 8.57 | 0.14 | 2.78*** |
| | After | 8.55 | 8.42 | 0.13 | 2.35** | 8.71 | 8.61 | 0.10 | 1.69* |
| Invest | Before | 1.61 | 1.42 | 0.19 | 3.42*** | 1.61 | 1.52 | 0.09 | 1.50 |
| | After | 1.61 | 1.40 | 0.21 | 2.31*** | 1.61 | 1.58 | 0.03 | 0.37 |
| Utility | Before | 1.55 | 1.34 | 0.21 | 3.56*** | 1.48 | 1.39 | 0.10 | 1.51 |
| | After | 1.55 | 1.38 | 0.17 | 2.33* | 1.48 | 1.37 | 0.12 | 1.46 |
| Appearance | Before | 0.59 | 0.48 | 0.11 | 2.31* | 0.51 | 0.41 | 0.10 | 2.14** |
| | After | 0.59 | 0.51 | 0.08 | 1.36 | 0.51 | 0.49 | 0.02 | 0.34 |
| Radius matching | | | | | | | | | |
| Output | Before | 2.33 | 2.11 | 0.22 | 3.44*** | 2.31 | 2.16 | 0.15 | 2.14** |
| | After | 2.33 | 2.13 | 0.20 | 2.63*** | 2.31 | 2.22 | 0.09 | 1.09 |
| Investment | Before | 8.55 | 8.44 | 0.11 | 2.34** | 8.71 | 8.57 | 0.14 | 2.78*** |
| | After | 8.55 | 8.42 | 0.13 | 2.37** | 8.71 | 8.60 | 0.11 | 1.81* |
| Invest | Before | 1.61 | 1.42 | 0.19 | 3.42*** | 1.61 | 1.52 | 0.09 | 1.50 |
| | After | 1.61 | 1.40 | 0.21 | 2.32*** | 1.61 | 1.58 | 0.03 | 0.45 |
| Utility | Before | 1.55 | 1.34 | 0.21 | 3.56*** | 1.48 | 1.39 | 0.10 | 1.51 |
| | After | 1.55 | 1.38 | 0.17 | 2.37** | 1.48 | 1.36 | 0.12 | 1.53 |
| Appearance | Before | 0.59 | 0.48 | 0.11 | 2.31** | 0.51 | 0.41 | 0.10 | 2.14** |
| | After | 0.59 | 0.51 | 0.08 | 1.36 | 0.51 | 0.49 | 0.02 | 0.28 |
5. Research Conclusions, Contributions, and Suggestions

5.1. Research Conclusion. Based on the “additionality effect” analysis framework, we use the PSM method to evaluate the impacts of the weighted deduction policy for research and development (R&D) expenses on innovation additionality, from the perspective of marketization, market competition, and political connections. The research has further verified the following: this policy can effectively stimulate the additionality of input and output, and it has a significant “additionality effect” on invention patents and utility patents, thus promoting high-quality innovation of firms. As moderation variables, low degree of marketization, high degree of market competition, and political connections positively regulate additionality effect of input and output brought by the weighted deduction policy for R&D expenses. Among them, the effect of low degree of marketization is contrary to the research findings of He Kang et al.

5.2. Research Contribution. Generally speaking, compared with the existing studies, we have at least the three following aspects of research contributions: (1) Combining the “additionality effect” analysis framework with the PSM method, we examined the real incentive effect of the weighted deduction policy for R&D expenses on the innovation of listed firms on the SME board and GEM and provided microempirical evidence based on Chinese practice. (2) The regulating mechanism of signal transmission is verified, which strongly supports the fact that the weighted deduction policy for R&D expenses can transmit signals of good development of firms to market in the background of information asymmetry, thereby helping firms to obtain innovation resources. In regions with low degree of marketization and high degree of market competition, the regulation effect of signal transmission is more significant, and political connections can transmit a signal of good political-business relationship, which will further strengthen the innovation and incentive effect of the policy. (3) The effect of the weighted deduction policy on firm innovation incentives is significant in multiple hypotheses, which strongly supports the policy’s reform orientation.

5.3. Recommendations

(1) As far as they are concerned, state-owned firms have natural endowment advantages in terms of political-
business relations in China. Other factors, such as whether there is high-tech enterprises’ identification, are likely to be one of the important factors in signal transmission. It is also worthy to verify the heterogeneity of innovation effects.

(2) In terms of policy implementation, firms should make full use of policy window periods. Meanwhile, to avoid R&D manipulation, the government should effectively supervise the behavior of firms and intermediaries. Building a clean political-business relationship will help strengthen signal transmission and optimize policy effects.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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