Has the R&D Extra Deduction Policy Stimulated the R&D Efficiency of Enterprises?–An Empirical Study based on Listed Chinese Manufacturing Enterprises

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Abstract: The regulatory advantages and incentive effects of tax preferential policies play an important role in building an innovative manufacturing power. Using the sample data of listed manufacturing enterprises and listed enterprises in the six major industries that had not enjoy the super deduction policy during 2016-2020, this paper takes the implementation of the super deduction policy of R & D expenses as a natural experiment, constructs a double difference model to empirically test the impact of tax incentives on R & D efficiency. The research finds that the super deduction policy has achieved the expected effect, and the R&D efficiency of manufacturing enterprises has been significantly improved; the incentive effect of the super deduction policy is heterogeneous, and the marginal effect of innovation efficiency of high-tech enterprises, state-owned enterprises, enterprises in the eastern region, large-scale enterprises and foreign-funded enterprises is higher. The article systematically discusses the promotion effect of the super deduction policy on manufacturing enterprises, and puts forward suggestions for optimizing tax policies, promoting technological innovation of manufacturing enterprises and building an innovative manufacturing power.

Keywords: Super deduction; enterprise innovation; R & D efficiency; double difference.

1. Introduction

The <Proposal of the Central Committee of the Communist Party of China on the formulation of the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Goals for 2035> emphasizes the need to promote the deep integration of the modern service industry with advanced manufacturing and modern agriculture, while also explicitly stating the importance of maintaining the proportion of manufacturing industry. On the one hand, the manufacturing industry is the foundation of economic growth (Han Haiyan, 2020)[1] and the cornerstone of stable and sustainable economic development for a country. On the other hand, the 19th National Congress of the Communist Party of China has clearly pointed out that innovation is the primary driving force for development and the strategic support for building a modern economic system. At the same time, innovation is also the driving force for high-quality development of the manufacturing industry (Xue Qing, 2022)[2]. In view of this, the government has been committed to enhancing the innovation capabilities of enterprises. In order to incentivize enterprises to invest in research and development, the government generally adopts two methods: direct government subsidies and tax incentives (Greenwald and Stiglitz, 1986)[3]. The former is constrained by special funds and is difficult to use flexibly, while the latter has relatively weaker constraints. Compared to subsidies, enterprises have greater autonomy in choosing tax incentives, which is conducive to unleashing their own potential, forming unique competitiveness, and playing a regulatory role of the market in enterprise innovation (Li Xin et al., 2019)[4]. The deduction of research and development expenses is a tax incentive implemented by the government to encourage enterprise research and development innovation. Therefore, exploring the relationship between the research and development expense deduction policy (hereinafter referred to as the "deduction policy") and the efficiency of enterprise research and development investment is of great practical significance for achieving enterprise development and building a manufacturing innovation powerhouse.

Innovation is the driving force behind stable economic growth, and corporate innovation can not only improve their own research and development system, but also enhance their research and development efficiency as a result. A considerable amount of research has been conducted on research and development efficiency, including research on measurement of research and development efficiency (Zhang Yu et al., 2017)[5], factors influencing research and development efficiency (Lin Qingning et al., 2018)[6], and evaluation of research and development efficiency (Zhou Shixin et al., 2022)[7]. Among them, factors influencing research and development efficiency have attracted much attention, involving both internal and external factors. Existing studies have shown that regional heterogeneity (Yang Haochang, 2019)[8], property rights heterogeneity (Liu Xiaoxuan et al., 2008)[9], enterprise size heterogeneity (Feng Haihong et al., 2015)[10], and government research and development funding (Fan Lingjun et al., 2014)[11] all have an impact on enterprise research and development efficiency. Although in recent years, the deduction of government research and development expenses has attracted the attention of scholars, relevant research has mainly focused on the impact of research and development expense deduction on research and development investment (Li Yihang et al., 2022)[12], firm performance (Wang Xi et al., 2020)[13], and the influence of financing constraints (Peng Huatao et al., 2021)[14], with less research on factors influencing research and development efficiency, and the underlying mechanisms still need further exploration. Existing studies have shown that the deduction policy can alleviate corporate financing constraints, reduce research and development costs and risks,
stimulate innovative research and development, and improve innovation efficiency and research and development capabilities (Rego, Wilson, 2013)[15]. Therefore, does the deduction policy for research and development expenses affect enterprise research and development efficiency? And what kind of impact does it have?

Based on the above analysis, this paper selects sample data from listed companies in the manufacturing industry that are applicable to the deduction policy for research and development expenses, as well as listed companies in six major industries that are not applicable to the deduction policy from 2016 to 2020. The research and development efficiency of enterprises is calculated using the traditional DEA model and the BBC model, and on this basis, a difference-in-differences (DID) model is constructed to analyze the relationship between the deduction policy and research and development efficiency in depth. At the same time, based on a multidimensional perspective, the impact of the deduction policy on research and development efficiency is comprehensively explored under the characteristics of industry, scale, property rights, investment subjects, and region. The implementation of the deduction policy reduces enterprise research and development costs, increases cash flow for business operations, and thus promotes corporate innovation (Wang Chunyuan, 2017)[16]. The research on the mechanism of the deduction policy's impact on research and development efficiency provides a new research perspective and theoretical explanation for the impact path of tax incentives on enterprise research and development output. This not only helps the government improve the accuracy of the deduction policy incentives, but also promotes the transformation and upgrading of manufacturing enterprises and high-quality development under the new normal.

2. Theoretical Hypothesis Proposed

2.1 The Incentive Effect of the Additional Deduction Policy

Romer[17] developed the endogenous economic growth model theory based on the Arrow[18] model theory. This theory suggests that endogenous technological progress is the driving force of economic growth, and entrepreneurial innovation activities are the main factors of technological progress. Market failure refers to the situation where the optimal allocation of resources cannot be achieved solely through the price mechanism of the market itself. In a market economy, the market plays a decisive role in resource allocation, but market regulation has inherent flaws and may result in suboptimal resource allocation. It is generally believed that public goods, monopolies, externalities, and information asymmetry contribute to market failure. In the process of entrepreneurial innovation, the existence of knowledge spillovers leads to private returns for firms that are much lower than social returns, which creates positive externalities. This has a restraining effect on firms' R&D investment, ultimately leading to levels of investment below the social optimum (Griliches, 1979; Yang et al., 2017)[19][20]. On the other hand, there are systematic risks in the process of entrepreneurial innovation, such as high R&D costs, long cycles, and technology leakage. Therefore, government intervention, often through tax incentives, is necessary to incentivize firms' R&D innovation, promote economic development, and achieve optimal resource allocation (Greenwald and Stiglitz, 1986)[21]. Among these intervention measures, the policy of tax deduction is considered the most fair and generous (He et al., 2019)[22].

In the process of entrepreneurial innovation and R&D, the policy of tax deduction generally has three main impacts. Firstly, by reducing the taxable income of enterprises through tax deduction, the policy transfers a portion of the R&D risks to the government, which enhances firms' motivation and capability to invest in R&D activities with high uncertainty and potential benefits. This, in turn, improves firms' innovation output and R&D efficiency. Secondly, the tax deduction policy represents a transfer of national tax revenue, and by lowering the costs of R&D for enterprises, indirectly increases their innovation benefits. This optimization of corporate financial constraints further drives firms' innovation output and R&D efficiency. Thirdly, as a government intervention measure, the tax deduction policy serves as a signal release mechanism, sending positive signals to financial institutions about the quality of firms. This mitigates information asymmetry in firms' innovation and R&D activities, thereby increasing capital market support for entrepreneurial innovation and alleviating firms' financing constraints. Ultimately, this promotes firms' innovation output and R&D efficiency. In summary, this paper proposes Hypothesis 1.

H1: The policy of additional deduction has a stimulating effect on the efficiency of enterprise research and development investment.

2.2 Heterogeneity Analysis of the Incentive Effects of the Additional Deduction Policy in Enterprises

From the perspective of enterprises, due to the heterogeneity of the enterprises themselves, as the main beneficiaries of preferential tax policies, enterprises will dynamically adjust their business strategies in accordance with policy and information changes to maximize profits. Therefore, the impact of tax incentive policies will also exhibit heterogeneity. From the perspective of the government, the scarcity of effective information and the complexity of dynamic markets pose challenges of "information asymmetry" for the government as the policy maker of tax incentives. Therefore, under the conditions of bounded rationality, the government may adopt a "one-size-fits-all" approach in the design and implementation process, reducing the choices available to enterprises and weakening the incentive effects for heterogeneous enterprises, and even leading to inhibitory effects. These situations partly contribute to the differences in the effectiveness of policy incentives.

2.2.1 Industry Heterogeneity Characteristics

The effect of the R&D tax deduction policy on the efficiency of enterprises' R&D activities may be influenced by industry characteristics. In the process of policy design and implementation, on the one hand, high-tech and non-high-tech enterprises are subject to different income tax policies, resulting in different effective marginal tax rates for enterprises. As a tax deduction incentive method, the
effectiveness of the R&D tax deduction policy is influenced by the effective marginal tax rate (Ren Haiyun and Song Wei, 2017)[23]. For high-tech industry enterprises, the tax policies are more favorable, and the actual marginal tax rate is lower, which to some extent offsets the implementation effect of the R&D tax deduction policy. On the other hand, for non-high-tech industry enterprises, due to more stringent tax policies, the actual marginal tax rate is higher. Under the condition of keeping other factors constant, the R&D tax deduction policy is beneficial for non-high-tech industry enterprises to save operational cash flow, reduce operating costs, and improve financing efficiency, which encourages innovation activities of non-high-tech industry enterprises, increases their R&D investment, and improves the efficiency of R&D investment. Furthermore, the innovation activities of high-tech enterprises are more frequent, and various factors at the industry and enterprise levels will affect enterprise innovation. Therefore, the impact of a single policy on enterprise innovation may be weaker. However, for non-high-tech industry enterprises, there are fewer factors at the industry and enterprise levels that affect innovation, so the incentive effect of the R&D tax deduction policy may be more pronounced. Based on this, Hypothesis 2 is proposed in this study.

H2a: The incentive effect of the additional deduction policy is more pronounced for non-high-tech enterprises.

2.2.4 Investment Subject Heterogeneity

The effect of the R&D tax deduction policy on the research and development activities may be influenced by enterprise size. In the specific process of enterprise operation, due to the heterogeneity of enterprise size, different-sized enterprises have different R&D resources, different levels of risk tolerance brought by R&D, and different R&D intentions, which result in different sensitivities to the R&D tax deduction policy and ultimately different incentive effects of the policy. For small-scale manufacturing enterprises, their market share is low, and their profits are relatively unstable, which leads to weak in-house R&D resources and difficulties in R&D financing. In addition, the lack of R&D experience and imperfect R&D management processes in small-scale enterprises make the incentive effect of the R&D tax deduction policy less pronounced. On the other hand, for large-scale manufacturing enterprises, their market share is high, and their profits are relatively stable, which results in strong in-house R&D resources, simple R&D financing, and more abundant R&D experience and improved R&D management processes. These enterprises can afford huge R&D expenses and bear R&D risks, thus making greater R&D investments. The R&D tax deduction policy can save more operating cash for them, and its policy effect is more pronounced. Based on this, Hypothesis 3 is proposed in this study.

H3b: The incentive effect of the additional deduction policy is more prominent for larger-scale enterprises.

2.2.3 Property Rights Heterogeneity

The effect of the additional deduction policy on the efficiency of enterprise research and development may be influenced by the nature of enterprise property rights. Due to the socialist market economy with Chinese characteristics, China has a large number of state-owned enterprises, and the operating goals of state-owned enterprises and non-state-owned enterprises are often different. In addition, there are differences in management mechanisms, market environments, resource conditions, and other aspects. Therefore, the incentive effects of the additional deduction policy may be different. In the actual operation process, state-owned enterprises may be subject to government intervention (Shleifer, 1994)[24], and they have multiple political goals such as stable employment, promoting growth, adjusting structure, and benefiting people's livelihoods. Therefore, they may abandon innovative activities with higher investment risks. In addition, state-owned enterprises have serious principal-agent problems (Wang Lei, et al., 2020)[25], which may lead to insufficient innovation intention of state-owned enterprises and thereby reduce the incentive effect of the additional deduction policy on state-owned enterprises. Non-state-owned enterprises, on the other hand, face a relatively harsh market environment and more intense competition, requiring constant development of new products, iteration of existing products, and occupying the commanding heights of patents. Therefore, they pay more attention to technological innovation. Furthermore, the management mechanisms of non-state-owned enterprises are more flexible, allowing them to quickly adjust their business strategies, innovation directions, and research and development priorities. Therefore, the additional deduction policy can effectively reduce the innovation costs of non-state-owned enterprises, alleviate the financing constraints faced by them, and thus improve their research and development efficiency. Based on this, Hypothesis 4 is proposed in this study.

H4c: The incentive effect of the additional deduction policy is more pronounced for non-state-owned enterprises.
development departments to China, increasing the research and development activities of foreign-funded enterprises in China, and improving their research and development efficiency. Based on this, Hypothesis 5 is proposed in this study.

H5d: The incentive effect of the additional deduction policy on foreign-funded enterprises is more pronounced.

2.2.5 Regional Heterogeneity

The effect of the additional deduction policy on the research and development efficiency of enterprises may be influenced by regional factors. China's economic development exhibits distinct regional heterogeneity, which is caused by various differences in geographical environment, cultural customs, factor endowments, policy factors, infrastructure, and other factors. Generally speaking, the more eastward, especially in the southeast coastal areas, the more developed the economy, the more mature the market that enterprises need, the faster the marketization process they face, and the greater the degree of industry competition (Li et al., 2019; Zhang et al., 2018)[4][27]. In order to gain comparative advantages in competition, enterprises in eastern regions pay more attention to technological innovation and research and development efficiency. Based on this, Hypothesis 6 is proposed in this study.

H6e: The incentive effect of the additional deduction policy on eastern enterprises is more evident.

3. Research Methods and Data Sources

3.1 Sample Selection

The Ministry of Finance, the State Administration of Taxation, and the Ministry of Science and Technology jointly issued the "Notice on Improving the Policy of Pre-tax Deduction of Research and Development Expenses" (Finance and Tax [2015] No. 119) in November 2015, which further refined the State Council's policy on the deduction of research and development expenses and expanded the scope of application for research and development activities. Therefore, this study takes the data of listed companies from 2016 to 2020 as the research sample, with the manufacturing industry in these enterprise samples as the treatment group, and the tobacco manufacturing industry, accommodation and catering industry, wholesale and retail industry, leasing and business services industry that are not applicable to the deduction policy as the control group. Based on this, a Difference-in-Differences (DID) model is established to verify the incentive effect of the deduction policy. The sample data were processed as follows: 1) excluding delisted and ST enterprise samples; 2) deleting samples with missing data; 3) truncating all continuous variables at the 1% level. Finally, 1,715 observations were obtained. The financial data of the sample companies mainly come from the WIND database, and information about the use of the deduction policy by companies was obtained through annual reports. Data cleaning and analysis were conducted using Stata 15.0 statistical software.

3.2 Dependent Variable Selection

Combining previous studies (Hou Jingjing, 2021; Huo Jianglin, 2018)[28][29], the dependent variable of this study adopts the research and development efficiency of listed enterprises calculated by data envelopment analysis (DEA). DEA was created by American operations researchers Charnes[30] and others to evaluate the efficiency between multiple input and output decision-making units (DMUs), that is, to determine whether the decision-making unit is on the “frontier” of the production possibility set. DEA calculates the comprehensive technical efficiency of decision-making units to determine whether their efficiency is valid. In addition, DEA can also determine whether the input scale of each decision-making unit is reasonable and provide directions for adjusting the input scale, thereby finding ways to improve efficiency from the input-output perspective. The traditional DEA model has two types: CCR and BCC models. By controlling factors such as capital and labor input, it regulates the research and development efficiency model and path of enterprises, but cannot control or intervene in the research and development efficiency of enterprises. Therefore, the BCC model (as shown in equation (1)) is selected, which is an input-oriented DEA model, to evaluate the research and development efficiency of listed companies. The research and development comprehensive efficiency value ranges from 0 to 1, and the closer it is to 1, the more effective the DEA is.

In the equation, and represents the input and output values of a certain decision-making unit, represents the decision variable, and respectively represent the slack variables for output and input, represents the efficiency value, represents the input factors of each decision-making units, and represents the output factors of each decision-making units. Long Zukun et al. (2015)[31] pointed out that when , the DEA of the decision-making unit is invalid; when and the slack variable is zero, the DEA of the decision-making unit is effective; when and the slack variable is zero, the DEA of the decision-making units is weakly effective. Based on the synthesis of previous research results (Hong Tu, 2020) [32] and the availability of data, the research input-output indicators are determined as shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Research and Development Efficiency Input-Output Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Input Indicators</td>
</tr>
<tr>
<td>Output Indicators</td>
</tr>
<tr>
<td>Indicators</td>
</tr>
</tbody>
</table>

3.3 Model Construction

In this paper, we investigate the role of the additional deduction system on the efficiency of enterprise research and development (R&D) using a double difference model (DID). The double difference model effectively avoids the endogeneity problem that exists when the policy variable is used as an independent variable in ordinary least squares (OLS). This method was first introduced by Ash-enfelter (1978)[33] in policy evaluation. The earliest domestic study to apply this method to policy evaluation was conducted by...
Zhou Lian and Chen Ye (2005)[34], who divided all samples into treatment and control groups. The samples affected by the policy were considered the treatment group, while the samples unaffected by the policy were considered the control group. Based on the relevant information of the treatment and control groups before and after policy implementation, the change in a certain indicator for the treatment group before and after policy implementation can be calculated, as well as the change in the same indicator for the control group. The difference between these two changes is then used to evaluate the effect of policy implementation. This is called the double difference model (DID), as it calculates the difference between the difference in the treatment group and the difference in the control group.

The double difference requires data to be measured for at least two periods. In this study, the enterprise samples were divided into a treatment group, representing the manufacturing industry eligible for the additional deduction policy and set as a dummy variable (Treat=1), and a control group, representing the tobacco manufacturing industry, catering industry, wholesale and retail industry, and leasing and business service industry, which are not eligible for the additional deduction policy, and set as a dummy variable (Treat=0). In addition, a dummy variable (Period) was set, with Period=0 representing the year before the implementation of the additional deduction policy. Therefore, the promotion effect of the additional deduction policy on the innovation of the treatment group before and after policy implementation (ΔYt) is the difference in innovation of the treatment group before and after the additional deduction policy implementation (ΔY0=α0). If the additional deduction policy has an incentive effect on innovation, the coefficient α1 should be significantly positive.

### Table 3: Meanings of Parameters in the Difference-in-Differences Model

<table>
<thead>
<tr>
<th>Group</th>
<th>Before (Period=0)</th>
<th>After (Period=1)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Industry (Treatment Group, Treat=1)</td>
<td>α0 + α1</td>
<td>α0 + α1 + α2 + α3</td>
<td>ΔYt = α1 + α2</td>
</tr>
<tr>
<td>Not applicable to tobacco manufacturing, accommodation and food service, wholesale and retail trade, leasing and business services (Control Group, Treat=0)</td>
<td>α0</td>
<td>α0 + α2</td>
<td>ΔYt = α2</td>
</tr>
</tbody>
</table>

### 4. Empirical Results

#### 4.1 Descriptive Statistics

The descriptive statistical test results of the enterprise sample obtained in this study are shown in Table 4. From the table, it can be seen that the maximum value of R&D efficiency (Crste) is 1, the minimum value is 0.045, the average value is 0.621, and the standard deviation is 0.287, indicating significant differences in R&D efficiency among the selected enterprises. The average value of return on assets (Roa) is 0.150, with a standard deviation of 0.510, indicating that although there are certain differences in competitive strength and development capability among the selected samples, overall these enterprises have a healthy profit-making ability. The average value and standard deviation of leverage (Lev) are 0.363 and 0.173, respectively, indicating that the sample enterprises face low financial risk and have good repayment ability. Company size (Size) is the logarithm of total assets, with a maximum value of 8.041, a minimum value of 11.411, an average value of 9.689, and a standard deviation of 0.497, indicating that the sample sizes are relatively similar. The average value of R&D expenditure (RD) is 0.052, with a standard deviation of 0.044, indicating that the sample enterprises have relatively low investment in innovative research and development.

### Table 4: Descriptive Statistics of the Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>mean</th>
<th>sd</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crste</td>
<td>1,715</td>
<td>0.621</td>
<td>0.287</td>
<td>0.045</td>
<td>1.000</td>
</tr>
<tr>
<td>Roa</td>
<td>1,715</td>
<td>0.150</td>
<td>0.510</td>
<td>0.000</td>
<td>5.030</td>
</tr>
<tr>
<td>Lev</td>
<td>1,715</td>
<td>0.363</td>
<td>0.173</td>
<td>0.001</td>
<td>0.802</td>
</tr>
<tr>
<td>Size</td>
<td>1,715</td>
<td>9.689</td>
<td>0.497</td>
<td>8.041</td>
<td>11.411</td>
</tr>
<tr>
<td>RD</td>
<td>1,715</td>
<td>0.052</td>
<td>0.044</td>
<td>0.000</td>
<td>0.582</td>
</tr>
</tbody>
</table>

#### 4.2 Parallel Trend Test

This study evaluates the impact of the additional deduction policy on R&D efficiency using a difference-in-differences model. Therefore, the changes in the control group and treatment group before the implementation of the additional deduction policy must be consistent. Based on the consistency...
of the remaining variables with the baseline regression analysis, this study defines dummy variables for the years after16, after17, after18, after19, and after20, and regresses them with the interaction term of Treat to test whether the two groups of samples satisfy the assumption of "parallel trends".

The regression results of the parallel trends test are shown in Table 5. From the table, it can be seen that the coefficients of the interaction terms of the dummy variables for the years 2017 and before are not significant, while the coefficient of the interaction term of the dummy variable for the year 2018, the year of policy implementation, is -0.0843, although not significant, it can still indicate the comparability of the two sample groups before the policy implementation. Since the sample statistics end in 2020, the dummy variable for that year is 0 and omitted in the regression results. In summary, the data of the two sample groups in this study comply with the assumption of "parallel trends", and the difference-in-differences method can be used to evaluate the impact of the additional deduction policy on R&D efficiency.

Table 5: Hypothesis Test for Parallel Trends

<table>
<thead>
<tr>
<th>Dependent Variable: Research and Development Efficiency of Enterprises</th>
<th>treat×after16</th>
<th>treat×after17</th>
<th>treat×after18</th>
<th>treat×after19</th>
<th>treat×after20</th>
<th>ROA</th>
<th>LEV</th>
<th>SIZE</th>
<th>RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0832</td>
<td>-0.2002</td>
<td>-0.0843</td>
<td>-0.0708</td>
<td>-0.67</td>
<td>0.4836</td>
<td>-0.1520</td>
<td>0.2715</td>
<td>-3.7924</td>
</tr>
<tr>
<td>(0.67)</td>
<td>(-0.91)</td>
<td>(-0.62)</td>
<td>(-0.67)</td>
<td></td>
<td></td>
<td>(3.81)</td>
<td>(-1.67)</td>
<td>(4.63)</td>
<td>(-7.83)</td>
</tr>
<tr>
<td>Year</td>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adj-r2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5828</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ***, **, and * respectively indicate significance at the 1%, 5%, and 10% levels; t-values are enclosed in parentheses. The same applies below.

4.3 Baseline Regression Analysis

Based on the established econometric model, this study conducted a baseline regression analysis on the sample data. The regression results are shown in Table 6. From the table, it can be seen that the coefficient of the interaction term of enterprise R&D efficiency (Crste) as the dependent variable is 0.0619 and significant at the 5% level. This indicates that under the impact of the additional deduction policy, the average increase in enterprise R&D efficiency is 0.0619 units and significant at the 5% level. The implementation of the additional deduction policy positively promotes R&D efficiency, consistent with the theoretical hypothesis of this study. In addition, the coefficients of total asset return (ROA) and firm size (Size) on research and development efficiency are 0.2796 and 0.3486 respectively, and they are significant at the 1% level. This suggests that, under the influence of the policy of additional deductions, the average increase in total asset return and firm size is 0.2796 and 0.3486 units respectively, and the impact of this policy is significant at the 1% level. In other words, the policy of additional deductions is conducive to increasing total asset return and expanding firm size. The core conclusion of this article remains unchanged.

Table 6: Baseline Regression Results

<table>
<thead>
<tr>
<th>Dependent Variable: Research and Development Efficiency of Enterprises</th>
<th>Periods×Treat</th>
<th>Constant</th>
<th>ROA</th>
<th>LEV</th>
<th>SIZE</th>
<th>RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0619**</td>
<td>(-2.31)</td>
<td>0.1845***</td>
<td>(5.30)</td>
<td>-0.2134**</td>
<td>(-2.45)</td>
<td>-2.3228**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.4 Robustness test

4.4.1 Narrowing the sample range

Different companies have differences in research and development innovation, financial characteristics, market environment, etc. at different time intervals. In order to test the robustness of the benchmark regression results, this study limits the research sample to data of listed companies from 2017 to 2019. The research takes research and development efficiency as the dependent variable and analyzes the impact of the policy of additional deductions. The robustness test results are shown in Table 7. It indicates that research and development efficiency has improved under the implementation of the policy of additional deductions. In addition, the coefficients of total asset return (ROA) and firm size (Size) on research and development efficiency are 0.2796 and 0.3486 respectively, and they are significant at the 1% level. This suggests that, under the influence of the policy of additional deductions, the average increase in total asset return and firm size is 0.2796 and 0.3486 units respectively, and the impact of this policy is significant at the 1% level. In other words, the policy of additional deductions is conducive to increasing total asset return and expanding firm size. The core conclusion of this article remains unchanged.

Table 7: Robustness Tests

<table>
<thead>
<tr>
<th>Dependent Variable: Research and Development Efficiency of Enterprises</th>
<th>Periods×Treat</th>
<th>Constant</th>
<th>ROA</th>
<th>LEV</th>
<th>SIZE</th>
<th>RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0340***</td>
<td>(3.61)</td>
<td>0.2796**</td>
<td>(4.26)</td>
<td>-0.4401***</td>
<td>(-3.03)</td>
<td>-2.1977***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.4.2 Placebo test

Different companies have many different characteristics. Although the previous identification controlled for the impact of all company characteristics that do not change over time by adding individual fixed effects, some characteristics may have different impacts over time, thus affecting the identification assumption. These impacts cannot be controlled by the model in this article. Therefore, in order to test whether the above regression results are affected by random factors or omitted variables, this article conducts random "selection" of...
manufacturing companies that "benefit from the policy of additional deductions" and randomly generates policy implementation time, thus constructing a two-level random experiment of policy implementation time and companies. Similarly, regression is performed according to Table 6, and the reliability of the conclusion is judged based on the probability of obtaining the baseline regression estimation coefficient in the false experiment. In order to further enhance the power of the placebo test, the above process is repeated 500 times, and finally, the distribution graph of the estimation coefficient of the coefficient treatxafter is drawn. Based on this, it is verified whether the research and development efficiency of manufacturing companies in China is significantly affected by factors other than the "policy of additional deductions". If the estimated coefficient distribution of treatxafter under random processing is concentrated around 0, it indicates that there is no serious omission of important influencing factors in the model setting. In other words, the effect on research and development efficiency in the benchmark regression analysis mentioned earlier is indeed the result of the policy focused on in this article. The estimation coefficient distribution graph reported in Figure 1 shows that the estimated coefficients of the false double difference term are concentrated around 0, indicating that there is no serious omission variable problem in the model setting, and the core conclusion remains robust.

4.5.1 Industry-specific regression

Different industries have different characteristics, which lead to differences in the technology and resources they possess, resulting in differences in the adaptability of the additional deduction policy. Therefore, this study uses industry nature as the classification criterion and divides companies into high-tech enterprises and non-high-tech enterprises to explore the impact of the additional deduction policy on R&D efficiency in different industry nature. The regression results of traditional industry nature are shown in Table 8, columns (1) and (2). The coefficient of the interaction term in column (1) is 0.4851 and significant at the 5% level, while the coefficient of the interaction term in column (2) is -0.0043, indicating that the additional deduction system has a significant incentive effect on the R&D efficiency of high-tech enterprises, but has an inhibitory effect on the R&D efficiency of non-high-tech enterprises, contrary to the hypothesis. The possible reason is that high-tech enterprises have advanced manufacturing technology, resources, and models, and the implementation of the additional deduction system is more conducive to highly coordinated material flow, information flow, and energy flow between them. Non-high-tech enterprises are limited by traditional production methods and processes, and the implementation of the additional deduction policy will disrupt the original production and operation balance, thus reducing R&D efficiency.

### 4.5 Heterogeneity Test

![Figure 1: Placebo Experiment](image)

#### Table 8: Heterogeneity Tests

<table>
<thead>
<tr>
<th>Project</th>
<th>Industry nature</th>
<th>Size</th>
<th>Property rights</th>
<th>Region</th>
<th>Investment subject</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High-tech</td>
<td>Non-high-tech</td>
<td>Above median</td>
<td>Below median</td>
<td>State-owned</td>
</tr>
<tr>
<td>Periodx</td>
<td>0.4851***</td>
<td>-0.0043</td>
<td>0.0726***</td>
<td>0.0349</td>
<td>0.0709*</td>
</tr>
<tr>
<td>ROA</td>
<td>0.2668***</td>
<td>-0.0132</td>
<td>0.0357***</td>
<td>0.0249</td>
<td>-0.0156</td>
</tr>
<tr>
<td>LEV</td>
<td>-0.1007*</td>
<td>0.3122*</td>
<td>-0.1523***</td>
<td>-0.0224</td>
<td>-0.3555***</td>
</tr>
<tr>
<td>SIZE</td>
<td>0.0494***</td>
<td>0.0960***</td>
<td>0.1290***</td>
<td>-0.0332</td>
<td>0.1229***</td>
</tr>
<tr>
<td>RD</td>
<td>-1.4777***</td>
<td>-8.4347***</td>
<td>-1.3634***</td>
<td>-1.2890***</td>
<td>-1.4506***</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0514</td>
<td>-0.2201</td>
<td>-0.5825**</td>
<td>0.9859**</td>
<td>-0.4213</td>
</tr>
<tr>
<td>Year</td>
<td>(-0.24)</td>
<td>(-0.51)</td>
<td>(-2.02)</td>
<td>(-6.30)</td>
<td>(-4.09)</td>
</tr>
<tr>
<td>Region</td>
<td>Control</td>
<td>Control</td>
<td>Control</td>
<td>Control</td>
<td>Control</td>
</tr>
<tr>
<td>Adj-r2</td>
<td>0.5674</td>
<td>0.1697</td>
<td>0.0874</td>
<td>0.0269</td>
<td>0.0804</td>
</tr>
</tbody>
</table>
4.5.2 Size-specific regression

The size of the company will affect the amount of R&D investment, the strength of R&D motivation, and the ability to bear risks, which will result in different elasticity of companies to the additional deduction policy and different effects on R&D efficiency. In this study, the median of the company samples is used as the threshold to divide the samples into above-median size and below-median size, in order to explore the impact of the proactive deduction policy on R&D efficiency in companies of different sizes. The regression results of size are shown in Table 8, columns (3) and (4). The coefficients of the interaction terms in columns (3) and (4) are 0.0726 and 0.0349, respectively, and companies above the median size are significant at the 5% level. This indicates that regardless of the size of the company, the additional deduction system has a positive promoting effect on R&D efficiency. However, compared to small-scale enterprises, large-scale enterprises have certain economies of scale, higher R&D capabilities and motivations, so the additional deduction system can better stimulate the R&D efficiency of large-scale enterprises.

4.5.3 Property rights regression

Different property rights lead to differences in corporate governance structures and business models, so the impact of the additional deduction policy may also vary. In order to further refine the research conclusions, this study classifies the company samples into state-owned enterprises and non-state-owned enterprises based on the two types of property rights, in order to study the impact of the additional deduction policy on R&D efficiency in different property rights. The regression results of property rights are shown in Table 8, columns (5) and (6). The coefficient of the interaction term in column (5) is 0.0709 and significant at the 10% level, indicating that the R&D efficiency of state-owned enterprises increases by an average of 0.0709 units under the influence of the additional deduction policy, and the policy effect is significant at the 10% level. The coefficient of the interaction term in column (6) is 0.0219. In summary, the incentive effect of the additional deduction policy on state-owned enterprises is more significant than that on non-state-owned enterprises. The possible reason is that non-state-owned enterprises face greater market competition pressure, have simple organizational structures, and flexible production and business models, which force excellent and successful non-state-owned enterprises to have good innovation and R&D capabilities on their own, so the incentive effect of the additional deduction policy on R&D efficiency is less. On the contrary, state-owned enterprises controlled by the government have a higher applicability of the additional deduction policy due to their behavior being influenced by government will and interests.

4.5.4 Regional regression

Due to factors such as geographical location, environmental climate, population distribution, and national policies, there are significant differences in economic development between different regions in China, which may result in variations in the impact of the additional deduction policy on enterprises in different regions. Therefore, this study classifies the sample of enterprises based on the regional economic development status, dividing them into the eastern and central-western regions, in order to study the heterogeneity of the impact of the additional deduction policy on research and development efficiency. The regional regression results are shown in Table 8, columns (7) and (8). The coefficient of the interaction term in column (7) is 0.0735 and significant at the 5% level, while the coefficient of the interaction term in column (8) is 0.0138 and significant at the 10% level. This indicates that the incentive effect of the additional deduction policy on enterprises in the eastern region is more significant compared to those in the central-western region. The reason for the difference between the eastern and central-western enterprises may be that the eastern region is more economically developed compared to the central-western region, and the enterprises in the eastern region have access to more abundant technology, funds, and human resources compared to the enterprises in the less developed central-western region. This makes the impact of the additional deduction policy on enterprises in the eastern region more significant.

4.5.5 Investment subject regression

The different investment subjects of enterprises lead to differences in the tax incentives they face, so the impact of the additional deduction policy on them also varies. Therefore, this study divides the sample enterprises into foreign-funded and non-foreign-funded based on the investment subjects, in order to study the heterogeneity of the impact of the additional deduction policy on research and development expenses under different investment subjects. The results of the investment subject regression are shown in Table 8, columns (9) and (10). The coefficient of the interaction term in column (9) is 0.0766 and significant at the 10% level, while the coefficient of the interaction term in column (10) is 0.0421. In conclusion, the additional deduction policy has a positive promoting effect on research and development efficiency of enterprises under different investment subjects, but foreign-funded enterprises, which have comparative advantages and resource allocation, show a more significant promotion effect due to more substantial tax incentives provided by the policy.

5. Research Conclusion and Suggestions

Innovation is the primary productivity, and enterprises cannot survive and develop in the long term without innovation. The government, as a strong "tangible hand" in the market, can promote the development of enterprise innovation through tax incentives. Therefore, quantitative research on the role of tax incentives in promoting enterprise research and development innovation can help the government formulate more perfect policies and further promote enterprise innovation. Based on this, this study takes the manufacturing industry as the treatment group and the tobacco manufacturing industry, accommodation and catering industry, wholesale and retail industry, and leasing and business service industry that are not eligible for additional deductions policy as the control group. The study uses a double difference model to empirically test the impact of additional deductions policy on research and development efficiency. The research conclusion shows that the additional deductions policy helps to improve the research and development efficiency of enterprises, and the results are
robust. Furthermore, this study excludes the influence of sample selection time interval, random factors, and omitted variables, narrows the sample range, and randomly selects enterprises and policy implementation time, and the results obtained are still robust. In addition, this study also investigates the differences in the effects of the policy in different industry types, different scales, different property rights, and different regions. The empirical results show that the promotion of research and development efficiency of high-tech, large-scale, state-owned and eastern enterprises is more strongly affected by the policy.

Based on the above research conclusions, this study gives the following suggestions: on the one hand, we should pay attention to the targeted nature of the policy, combine the heterogeneity of the additional deductions policy, and formulate differentiated preferential systems and encouragement policies for enterprises in different regions, different scales, different property rights, and different industry types. Fully consider the characteristics of non-state-owned enterprises located in inland areas with limited technological level, so as to improve their sensitivity and applicability to the additional deductions policy, and strengthen the incentive effect of the policy on enterprise innovation and research and development. At the same time, the development of small and medium-sized enterprises is also an indispensable part of the post-pandemic era. Promoting and supporting small and medium-sized enterprises is an important strategic task related to the well-being of the people and the future of the nation. Therefore, when improving and implementing tax incentives policies, the subsidies for small and medium-sized enterprises should be increased, the deduction ratio of research and development expenses under the additional deductions policy should be increased, the accounting and declaration procedures should be simplified, and the investment in research and development by small and medium-sized enterprises should be increased. On the other hand, the government should actively promote the transformation and upgrading of industrial policies, reduce intervention in the market, and create a good and reasonable market competition environment for enterprises. Provide support for transformation enterprises from political, economic, social, and technological aspects. At the same time, deepen market-oriented reforms, improve the mixed ownership reform mechanism of state-owned enterprises, establish performance evaluation indicators for innovation and research and development, create a good institutional environment for the transformation and implementation of tax incentives policies, and further stimulate enterprise innovation.

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