

R&D Deduction Intensity, Entrepreneurship and Total Factor Productivity of Firms

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Abstract: This paper selects A-share listed manufacturing companies from 2016 to 2022 for analysis, and uses the data to investigate the interrelationships among three dimensions: the strength of R&D add-on deduction, entrepreneurship, and total factor productivity of firms. The aim is to explain the policy implementation effects of China's R&D add-on deduction policy since the 1990s. This paper examines the significant effect of the strength of the add-on deduction policy on enhancing the total factor productivity of firms and the positive moderating role of entrepreneurship in the impact of the strength of R&D add-on deduction on the total factor productivity of firms. The purpose of this paper is to provide a realistic basis for the national policy of optimizing R&D cost-added deduction to promote high-quality development of China's listed manufacturing industry.

Keywords: R&D cost-added deduction policy, Entrepreneurship, Total factor productivity of enterprises.

1. Introduction

In the 21st century, China's economic development model has undergone a transition from a period of rapid growth to one that emphasizes high-quality development. The report of the 20th Party Congress has emphasized the necessity of enhancing total factor productivity (TFP) as a crucial means to achieve China's high-quality economic growth. According to Cheng Huifang and Lu Jiajun(2014), TFP is primarily influenced by three factors: efficiency improvement, scale effects, and technological advancement, with the latter being regarded as the fundamental driving force behind TFP enhancement. Unlike conventional measures of single-factor productivity, TFP provides a comprehensive framework that integrates various elements, thereby establishing a solid foundation for formulating and evaluating long-term sustainable growth policies.

At present, numerous studies focus on the mechanisms of corporate TFP, recognizing its central role in technological innovation. Technological innovation, in turn, heavily relies on institutional reforms and national policy support. To foster enterprise innovation, the Chinese government has introduced several tax incentives, with the policy of R&D expense deduction assuming a significant role. Since 1996, China has implemented policies allowing R&D expense deductions, which have played a crucial role in encouraging increased R&D investment by enterprises, advancing technological innovation across society, and stimulating the vitality of the market economy. The implementation of these policies has incentivized enterprises to augment their R&D investments, thereby promoting innovation and technological progress. Such progress contributes to the enhancement of TFP, as the application of new technologies can improve resource utilization efficiency in the production process and enhance the quality and effectiveness of products and services. Innovation serves as a cornerstone for companies to establish themselves in a complex and volatile economic environment and acts as a driving force behind steady TFP growth.

Starting from 2023, the R&D add-on deduction policy in the manufacturing sector mandates that companies fully

deduct actual R&D expenses when calculating pre-tax profits. This policy compels enterprises to transform and upgrade their manufacturing sectors, with the aim of reducing production costs and enhancing competitiveness. Enterprises must prioritize R&D investment to elevate their technological prowess, enabling them to continue innovating and maintaining market competitiveness. Simultaneously, the introduction of this policy compels enterprises to escalate their investments in research and development, thereby accelerating the pace of independent innovation. By increasing R&D investment, enterprises can bolster technological research and development, refine product quality and production efficiency, expand their market shares, and explore new business prospects. Thus, the R&D add-on deduction policy and TFP reciprocally interact and influence each other, even providing significant impetus to enterprises. This policy endows enterprises with additional resources and motivation to spearhead breakthroughs in technological innovation and market competition, thereby further propelling China's economic development, transformation, and upgrading.

Then, the promotion of high-quality development in the manufacturing industry in a sustainable and robust manner hinges not only on policy support but also on the role of individuals. Drawing upon Schumpeter's innovation theory, entrepreneurs, as the driving force behind innovation, achieve economic growth through "creative destruction" activities, which encompass novel combinations of production factors, discoveries of untapped markets, technological advancements, and organizational restructuring, among others. Brauner Hjelm et al.(2010) argue that a filter exists between general knowledge and economically relevant knowledge, impeding the transformation of the former into the latter. Entrepreneurs, however, have successfully weakened this filter by initiating new enterprises, reconfiguring production factors, and adopting new technologies and business models. Such endeavors have fostered knowledge production and dissemination, making notable contributions to economic growth rates and innovation capabilities.

Since the initiation of economic reform and opening up,

entrepreneurship has undergone continuous enrichment, transitioning from a focus on individual entrepreneurship to emphasizing entrepreneurship at the organizational level within the broader economic environment. This new paradigm highlights the importance of win-win entrepreneurship that can propel both macroeconomic development and the growth of micro-enterprises. It serves as a catalyst for the shift from an innovation-driven economy to one that is innovation-led.

In the contemporary economic landscape, the ability of entrepreneurship to influence research and development (R&D) add-on deductions and, consequently, promote corporate total factor productivity (TFP) assumes paramount importance. This paper aims to investigate the underlying mechanisms that facilitate this essential influence. To this end, a fixed panel regression model is employed to empirically analyze the moderating effect of R&D add-on deductions, specifically pertaining to entrepreneurship, on corporate TFP. The findings of this study will offer valuable insights to other scholars, while also proposing relevant measures and countermeasures to inform future research and policy decisions.

2. Theoretical Basis and Research Hypothesis

2.1. R&D add-on deduction and corporate TFP

To foster scientific and technological advancement and facilitate developmental growth, the Chinese government has implemented a policy aimed at bolstering research and development (R&D) investments through the provision of tax deductions. This policy serves the purpose of furnishing tax incentives that effectively steer enterprises towards more proactive engagement in R&D endeavors. By permitting enterprises to deduct a supplementary proportion of their actual R&D expenditures from their income tax calculations, this initiative diminishes their tax obligations and augments their post-tax earnings. As a result, this measure has not only broadened the avenues for enterprise financing but also conferred substantial financial aid, thereby contributing to a qualitative enhancement in total factor productivity (TFP).

Technological progress serves as a crucial catalyst for Chinese manufacturing enterprises to achieve a trajectory of high-quality development. Conceptually, the ramifications of the strength of research and development (R&D) cost-plus deduction on the degree of enterprise total factor productivity (TFP) enhancement can be elucidated from three distinct perspectives. Firstly, the earnings effect, as expounded by Zheng Baohong and Zhang Zhaoguo(2018), underscores the tax-based preferential policy of R&D expense deduction, which not only augments post-tax net income for enterprises but also facilitates expanded financing avenues, thereby alleviating restrictive conditions. Consequently, enterprises experience reduced financial pressures in their pursuit of R&D investments, effectively bolstering their corresponding endeavors. This practical policy endows enterprises with substantial tax benefits, thus further galvanizing their investments in emerging technological domains. Moreover, Xianhuan Huang and Yao Wang [4] posit that changes in objective policies leading to an upsurge in cash stockpiles and a reduction in the financial burdens associated with business operations and R&D activities contribute to the decrease in cash outflows. By providing ample financial support,

enterprises are incentivized to amplify factor inputs for expansion and reproduction. Secondly, the reduction of technological innovation risk assumes significance. The works of Feng, Haihong et al.(2015) and Mukherjee et al. (2017) underscore that insufficiently high R&D deduction intensity fails to compensate for the risks and spillover externalities associated with R&D activities, thereby significantly curbing enterprises' motivation and autonomy to invest in R&D, consequently impeding TFP growth. Deducting R&D expenses mitigates the income tax burden on enterprises to a certain extent, effectively sharing the technological innovation risk with the government. This stimulates enterprises' impetus for technological innovation and, fundamentally, the implementation and execution of this policy further engenders enterprise TFP growth. Thirdly, the absorption capital effect, as identified by Shen X et al.(2019) elucidates that firms' investment in R&D costs heightens the assimilation of knowledge and skills possessed by intermediate-level technical staff, thereby enhancing firm TFP. Burda and Severgnini (2018) discovered an inverse relationship between a firm's R&D investment intensity and its TFP, i.e., a negative correlation. However, if R&D investments successfully absorb a substantial amount of intellectual capital effects and elevate the proficiency of technicians, the firm's TFP experiences a significant upswing. It is worth noting that excessive intensity in R&D expenses may result in resource overinvestment and managerial challenges, consequently generating adverse effects and negatively impacting firm TFP. This may stem from inefficiencies in R&D activities, heightened technological risks, and uncertainties in market demand. However, when firms adeptly assimilate the intellectual capital engendered through R&D investments, their TFP experiences a substantial boost. Empirically, the relationship between R&D expenses and TFP has been extensively studied from a firm-oriented perspective. Research conducted by Chuncheng Lu et al. (2023)Liu Ye and Lin Chen Dan (2021), and Kaiser (2002)has demonstrably showcased the significant positive impact of R&D investment on TFP improvement. Building upon this foundation, the ensuing hypotheses are put forth:

H1: The intensity of R&D add-on policy significantly boosts corporate TFP

2.2. R&D add-on deduction, entrepreneurship and corporate TFP

Theoretically, entrepreneurship plays a pivotal role in propelling economic development, fostering technological innovation, and enhancing productivity. Entrepreneurship encompasses the attributes and conduct of entrepreneurs, including their capacity for innovation, risk-taking, and identification and exploitation of opportunities. A multitude of studies have demonstrated that entrepreneurship can cultivate a fresh organizational culture and facilitate the optimization of corporate Total Factor Productivity (TFP) through the effective allocation of corporate resources. On one hand, Zhuang Ziyin(2005) has revealed that the relative rewards associated with different economic activities influence the allocation of entrepreneurial endeavors, subsequently influencing the level of investment in research and development (R&D) as well as technological advancements. These, in turn, have a profound impact on innovation performance and long-term growth rates. On the other hand, Gries et al.(2010) contend that the opportunity-driven vigor of entrepreneurship is imperative for the

expansion and advancement of firms. Entrepreneurs drive firm progress by consistently pursuing innovation, providing intermediate goods and services, generating employment opportunities, and enhancing productivity. This positive manifestation of entrepreneurship has precipitated the transformation of the economy from traditional to modern sectors, resulting in the revitalization and optimization of the industrial structure, and a rapid surge in economic development. Furthermore, as per Minniti et al.'s classification(2010), entrepreneurs engaged in research and development (R&D) and imitative entrepreneurship employ distinct strategies to attain business growth and development. R&D entrepreneurs are dedicated to the development of novel technologies, products, or services that cater to evolving market needs. This inclination toward innovation enables firms to consistently introduce new or enhanced products, thereby gaining a competitive edge and satisfying consumer demand. Concurrently, investment in R&D can augment a firm's technological prowess and productivity, significantly elevating its core competitiveness. In contrast, imitative entrepreneurs primarily rely on technology replication to lower costs, reduce prices, and enhance efficiency. By assimilating and emulating existing technologies, products, or business models, they achieve rapid replication and expedited market entry. While this imitation strategy may yield short-term success, it lacks genuine competitive advantage.

In the era of information technology, entrepreneurship serves as the fundamental pillar of enterprises within the realm of high-quality development. Its influence on the policy of R&D expense deduction and total factor productivity (TFP) is immensely significant. Firstly, Pan Jianping et al.'s (2015) posits that in the present landscape of rapidly evolving economics, enterprises must engage in continuous innovation to uphold their competitive advantage and achieve sustainable long-term growth. The entrepreneurial spirit of innovation can invigorate the potential and creativity of employees, fostering a climate of perpetual innovation and advancement within the company. Consequently, this fosters a more dynamic and competitive corporate culture and values. In the rapidly changing economic landscape, the attainment of high-quality corporate development necessitates even more remarkable entrepreneurial innovation.

Secondly, according to Yongli Liu (2020), business capability within entrepreneurship is a pivotal element intricately interwoven throughout the entire process of resource allocation and management within an enterprise. In the absence of robust business capability, it is highly plausible that the resource allocation of the enterprise will become imbalanced, resulting in the irrational allocation of resources and a decline in the enterprise's TFP. Hence, exceptional entrepreneurs must possess outstanding management capabilities to effectively plan and manage resources within the enterprise, thereby significantly enhancing the efficiency and competitiveness of the enterprise.

Thirdly, as elucidated by Lafuente's(2016) study, entrepreneurs, upon identifying market opportunities, leverage their unique human capital to integrate various factors of production, thereby facilitating knowledge spillovers that are indispensable and play a crucial role in augmenting TFP. Although entrepreneurs may not be directly engaged in research and development activities, they indirectly participate in and promote scientific and technological innovation through resource allocation and the mobilization of production factors. The augmentation of this

knowledge spillover effect contributes to the enhancement of TFP.

To summarize, this paper postulates the following hypotheses:

H2: Entrepreneurship plays a positive moderating role in the impact of R&D deduction intensity on firm TFP.

2.3. Heterogeneity analysis of the intensity of R&D cost-added deduction on firms' TFP

2.3.1. The impact of enterprise size

To begin with, enterprises require substantial capital to support the initial stages of research and development (R&D), which introduces a degree of uncertainty regarding the attainment of anticipated outcomes. Smaller enterprises, characterized by less robust R&D teams and less refined R&D processes in comparison to larger counterparts, face elevated R&D risks. Consequently, the impact of the R&D expense deduction policy on these smaller enterprises is even more pronounced, leading to a greater reduction in their risks.

Furthermore, enterprises that enjoy substantial profits may not experience significant tax-saving effects, resulting in minimal benefits from the R&D add-on deduction policy. Conversely, enterprises with modest profits perceive a greater advantage in terms of profit gains from the tax reduction policy. Due to the scale effect, smaller and medium-sized enterprises typically yield lower profits. Consequently, the tax-saving effect holds substantial significance for enterprises with modest profits, underscoring the urgent need for prompt implementation of the R&D add-on deduction policy.

Lastly, Yang Hongtao et al. (2015) concluded that large enterprises exhibit stronger profitability compared to small and medium-sized enterprises. The disadvantages faced by the latter category encompass limited financing channels and a weaker capacity to withstand risks. Consequently, small and medium-sized enterprises display heightened responsiveness to policy initiatives compared to their larger counterparts. In summary, the following hypotheses are proposed in this paper:

H3a: R&D add-on deductions are better at boosting TFP for SMEs

2.3.2. The influence of the nature of enterprise property rights

Firstly, owing to the distinct characteristics of property rights, enterprises encounter varying levels of innovation risks throughout the research and development (R&D) process. Given the distinctive market position of state-owned enterprises (SOEs), their association with government departments is more intimate, thereby resulting in a weaker awareness of market competition and innovation. Furthermore, the lenient budget constraints faced by SOEs foster a higher tolerance for risk and a reduced sensitivity towards the benefits generated by technological innovation, thereby leading to comparatively lower engagement in R&D endeavors. Secondly, research conducted by Sheng Mingquan et al.(2020) indicates that non-SOEs exhibit greater market sensitivity and a stronger inclination towards procuring novel products and technologies to enhance their core competitiveness. Lastly, Wu Yanbing's(2012) investigation reveals that due to the inherent characteristics of SOEs and the prevalence of a significant principal-agent relationship, the primary objective for SOE managers tends to revolve around maximizing their personal earnings during their tenure. However, the inherent uncertainty and riskiness associated with innovation tend to diminish the motivation of SOE managers to actively partake in R&D activities.

H3b: R&D add-on deduction intensity re-increases TFP by enterprise property rights heterogeneity

2.3.3. The impact of corporate financing constraints

In order to bolster investments in research and development (R&D) endeavors, enterprises must secure substantial funding commitments. Consequently, the decision of whether to engage in R&D activities is influenced by financial limitations faced by these enterprises. The strength and proactive nature of enterprises in responding to the R&D add-on deduction policy initiative are directly proportional to the extent of these financing constraints. Notably, Tang et al. (2018) have demonstrated that a reduction in financing costs, resulting from advancements in the banking sector, constitutes a primary avenue for enhancing total factor productivity (TFP) within China's industrial sector, thereby promoting R&D-driven innovation. Similarly, Du (2022) contends that the augmentation of enterprises' innovative R&D activities primarily hinges upon internal funds, while the implementation of a favorable R&D cost-added deduction policy incentivizes enterprises to actively undertake technological upgrades and other innovative pursuits. Furthermore, the alleviation of financing constraints is also influenced to some degree by the R&D cost-added deduction. Notably, the response is more pronounced among enterprises facing more substantial financing constraints. Building upon this rationale, this study adopts the understanding of financing constraints presented by Hadlock and Pierce(2010) in conjunction with Ju et al. (2013) to develop the SA value indicator as a proxy variable for measuring financing constraints. The calculation of this indicator involves:

$$SA=0.043\times Size^2-0.737\times Size-0.04\times Age \quad (1)$$

where SA is a negative value. In summary, the following hypothesis is proposed in this paper:

H3c: R&D add-on deduction is better to enhance financing constrained larger TFP

2.3.4. The factor of geographical location

Several scholars have conducted research on the impact of state-provided tax policies regarding R&D expenses at the firm level. They have discovered that these policies have a spillover effect, which serves as a crucial mechanism for enhancing a firm's overall production factors. The geographical location of the firm plays a significant role in this spillover effect. For instance, Aiello and Cardamone(2008), drawing on the theory of public goods and utilizing data from Italian industrial firms, have observed that the firm's geographic location influences the technology spillover effect to some extent. Becker-Blease(2011) has suggested that geography affects information asymmetry and transaction costs in economic behavior, subsequently impacting firms' Total Factor Productivity (TFP). Cheng Chen(2017) argues that the promotion of TFP through technological innovation spillover primarily arises from technologically backward enterprises imitating advanced technology and technologically advanced enterprises investing significantly in technological innovation. Developed provinces with well-functioning technology markets and a favorable innovation climate are better able to facilitate the assimilation of external information and knowledge by enterprises, as well as assist technologically advanced firms in minimizing the loss of innovation externalities. Consequently, this environment enhances enterprises' motivation to engage in R&D and innovation,

thereby promoting improvements in TFP. Based on these insights, this paper proposes the following hypotheses:

H3d:R&D add-on deduction intensity enhances the full range of factors of enterprises with geographical regional heterogeneity.

3. Study Design

3.1. Data sources and data processing

The Notice on Enhancing the Policy of Pre-tax Deduction for Research and Development Expenditures introduces specific enhancements to the pre-tax deduction of R&D expenses, proposes the implementation of a negative list system, and further broadens the scope of R&D expenditure collection and recognition. Consequently, this paper establishes the year 2016 as the starting point for the research. Regarding the composition of R&D investment, the majority of large-scale industrial enterprises are concentrated in the manufacturing sector. Taking into consideration the availability of R&D expenditure data, this study selects A-share manufacturing listed companies as the research sample, covering the period from 2016 to 2022. The necessary data for the research is sourced from the CSMAR database. To ensure estimation accuracy and mitigate the impact of outliers and heteroskedasticity, the relevant variables undergo a series of statistical treatments, including 1% tail-shrinking, decentering, and natural logarithm transformation. Consequently, a dataset comprising 9226 observations from 1318 listed manufacturing companies is obtained.

3.2. Variable selection

3.2.1. Explained variables

Currently, the predominant approaches for assessing enterprise Total Factor Productivity (TFP) include the OP method and the LP method. However, the OP method necessitates a requirement for a strictly increasing association between investment and productivity, resulting in the inability to estimate TFP for enterprises with zero investment. In response to this limitation, the LP method builds upon the OP method by utilizing intermediate goods input as a proxy variable. This augmentation enhances the flexibility in the selection of proxy variables. Consequently, in accordance with the investigation conducted by Lu and Lian Yujun(2012), this study opts for the employment of the LP method to gauge firms' TFP. Furthermore, to bolster the robustness of the analysis, the OP method is subsequently employed as a supplementary investigation tool. The implementation of the LP method is outlined as follows:

$$\ln Y_{it} = \alpha \ln L_{it} + \beta \ln K_{it} + \gamma \ln M_{it} + \varepsilon_{it} \quad (2)$$

Where Y, L, and K denote the aggregate output of the firm (representing the firm's operating income), capital input (net fixed assets), and labor input (number of employees), respectively, while M represents an intermediate variable encompassing various factors, namely operating costs, selling expenses, administrative expenses, financial expenses, depreciation and amortization, and cash disbursements for employee compensation.

3.2.2. Explanatory variables

The magnitude of the policy regarding the additional deduction for research and development (R&D) expenses is a significant determinant. Reference can be made to Ren, Can-

Can et al. (2021) and Du Qianqian et al. (2022). The specific formula employed is as follows: R&D expenditure multiplied by the deduction ratio, then multiplied by the income tax rate, and divided by the total assets of the enterprise. The calculation formula is given by: R&D expenditure multiplied by the additional deduction ratio, then multiplied by the income tax rate, and divided by the total assets of the enterprise. The deduction ratio was set at 50% for the period of 2016-2017 and increased to 75% for the period of 2018-2022. The income tax rate corresponds to the nominal tax rate of the enterprise in the present year.

3.2.3. Moderating variables

The definition of entrepreneurship lacks clarity and uniformity, with existing measures encompassing the self-employment ratio and entrepreneurship composite index. To holistically capture the essence of entrepreneurship and consider the research objectives and data availability of this paper, the present study draws upon the entrepreneurship index constructed by Ye Zuoyi and Wu Wenbin (2018). Moreover, the work incorporates the findings of Zhang Li et al. (2021) to comprehensively evaluate entrepreneurship. Specifically, this paper assesses entrepreneurship from three dimensions: business ability, entrepreneurial ability, and innovation ability. Indicators such as the number of enterprise patents, per capita fixed assets, per capita intangible assets, per capita business income, and board of directors' independence are selected. The entropy weighting method is employed to assign weights to these indicators for the calculation of entrepreneurship. Among them, the number of enterprise patents directly reflects the innovation capacity and effectiveness within the enterprise, serving as a direct manifestation of the entrepreneurial spirit's innovative nature. Per capita fixed assets, intangible assets, and business income, which reflect entrepreneurial business ability, signify an entrepreneur's capacity to identify market opportunities. Additionally, the independence of the board of directors measures whether the enterprise displays self-employment tendencies, thereby indicating the entrepreneur's personal entrepreneurial prowess.

3.2.4. Control variables

This paper incorporates a range of additional variables that could potentially influence R&D add-on deductions. Drawing upon the works of Ren, Can-Can et al. (2021) and Qianqian Du et al. (2020), the following indicators were carefully chosen for this study. Firstly, in order to examine the alleviation of financing constraints experienced by enterprises as a result of R&D investment, the gearing ratio was introduced as a control variable. The gearing ratio (Lev) is calculated by dividing total liabilities by total assets, and it serves as a measure of enterprises' ability to secure funds from creditors for their operations. Secondly, to assess the changes that occur in enterprises' operations following their R&D investment, the study incorporates the current asset turnover ratio, main business profit margin, growth, and the asset capture ratio. The current asset turnover ratio (tca), obtained by dividing average current assets by operating revenue, serves as an indicator of the company's efficiency in utilizing its current assets. A higher value of this indicator signifies greater asset utilization efficiency. The main operating profit margin (mpm), obtained by dividing main operating profit by operating revenue, measures the profitability of the company's core business. A higher value of this indicator suggests greater profitability. Cash-on-assets (Cash) is calculated by dividing net cash flow from operating activities by average total assets, and it measures the efficiency of the company's asset utilization in generating cash. Growth indicates the growth rate of sales compared to the previous year, providing insights into the company's overall growth. Age of listing (AGE) is determined by subtracting the listing year from the sample year and adding one, then taking the logarithm of the result. Lastly, the nature of ownership (SOE) is included to differentiate state-owned enterprises, collective enterprises, etc., from private enterprises. State-owned enterprises significantly differ from private enterprises in terms of government support, loan interest rates, as well as their motivation for technological innovation and productivity enhancement. The specific calculation formula is presented in Table 1 for reference.

Table 1. Definition of main variables

Type	Name	Symbols	Specific calculation formula
Explained variables	Corporate TFP	TFP	LP Method
Explanatory variables	R&D add-on deduction intensity	TAX	$(\text{R\&D expenditure} * \text{deduction rate} * \text{income tax rate}) / \text{Total assets of the enterprise}$
Adjustment variables	Entrepreneurship	Ce	Entropy method
Control variables	Current asset turnover ratio	tca	Operating income/average current assets
	Profit margin from main business	mpm	Profit from main business / Operating income
	Asset Cash Flow Rate	Cash	Net cash flow from operating activities/total average assets
	Gearing ratio	Lev	Total liabilities/total assets
	Growth	Growth	Sales growth rate relative to the previous year
	Age of listing	AGE	Sample year minus listing year plus 1 is taken as the logarithm
	Nature of ownership	SOE	State-owned enterprises take 1 Non-state-owned enterprises take 0
	Industry	Industry	Industry dummy variables
	Annual	Year	Annual dummy variables

3.3. Model construction

3.3.1. Baseline regression model

In order to test the relationship between the intensity of R&D add-on deduction and the impact of firm TFP, referring to Guo Jian et al.[32][32]'s study to construct model (3):

$$TFP_{it} = \beta_1 + \beta_2 TAX_{it} + \alpha Controls_{it} + \mu_i + \tau_t + \varepsilon_{it} \quad (3)$$

In model (3), TAX is the R&D add-on deduction intensity, Controls denotes the control variables as shown in Table 2, τ and μ represent firm and time, respectively, τ represents individual fixed effects, μ represents time fixed effects, and ε represents random error terms.

3.3.2. Analysis of the mechanism of regulation effect.

In order to test hypothesis 2, the interaction term of R&D deduction intensity and entrepreneurship is added to model (4).

$$TFP_{it} = \alpha_1 + \alpha_2 TAX_{it} + \alpha_3 Ce_{it} + \alpha_4 Ce_{it} \times TAX_{it} + \alpha Controls_{it} + \mu_i + \tau_t + \varepsilon_{it} \quad (4)$$

In model (4), TAX is R&D add-on deduction intensity, Ce is entrepreneurship, τ and μ represent firm and time, respectively, τ represents individual fixed effects, μ

represents time fixed effects, and ε represents random error term.

3.4. Empirical results

3.4.1. Descriptive statistics

Table 3 presents the descriptive statistics of the variables: the mean value of TFP calculated under the LP method is 6.240 with a standard deviation of 0.732. the mean value of R&D deduction intensity is 9.151 with a standard deviation of 1.43, the maximum value is 14.54 and the minimum value is 0.314, which indicates that the overall difference in the preferences of R&D deduction policies in China is large, which laterally indicates that most Chinese enterprises have R&D awareness and actively take actions to carry out measures corresponding to enjoying the R&D add-on policy and actively invest in R&D. The mean value of entrepreneurship (CE) is 0.146, the minimum value is 0.0375, and the maximum value is 0.748. This result indicates that the degree of entrepreneurship exhibited by enterprises varies among enterprises, and the entrepreneurship exhibited by most enterprises is still in the primary stage. The correlation coefficients among the above variables are all significantly correlated at the level of less than 5%, which tentatively confirms the basic hypothesis of this paper.

Table 2. Descriptive statistics

Variables	Number of observations	Median	Standard deviation	Minimum value	Maximum value
tfp	9,226	6.240	0.732	3.132	9.544
TAX	9,226	9.151	1.430	0.314	14.54
Ce	9,226	0.146	0.0704	0.0375	0.748
tca	9,226	1.210	0.853	0.0242	14.74
mpm	9,226	5.074	140.5	-6093	10194
cash	9,226	0.0527	0.0672	-0.556	0.874
lev	9,226	0.417	0.196	0.00840	2.849
growth	9,226	0.195	1.316	-0.913	58.84
age	9,226	2.913	0.293	1.792	3.989
soe	9,226	0.318	0.466	0	1

4. Regression Results

4.1. Baseline regression test

Table 3 presents the descriptive statistics pertaining to the variables. The TFP mean value, calculated using the LP method, is 6.240, accompanied by a standard deviation of 0.732. In terms of R&D deduction intensity, the mean value is 9.151, with a standard deviation of 1.43. The maximum value recorded is 14.54, while the minimum value is 0.314. This significant range signifies substantial disparities in preferences for R&D deduction policies within China. Consequently, it indicates that the majority of Chinese enterprises exhibit a strong inclination towards R&D, actively engaging in measures aligned with the R&D add-on policy, and investing significantly in research and development activities. Regarding entrepreneurship (CE), the mean value is 0.146, with a minimum of 0.0375 and a maximum of 0.748. These results imply that the level of entrepreneurship demonstrated by enterprises varies among them, with most enterprises still in the nascent stage of entrepreneurship development. Furthermore, all the aforementioned variables

exhibit significant correlations, confirmed at a significance level of less than 5%. This preliminary validation lends support to the fundamental hypothesis posited in this study.

4.2. Moderating effect test

The results pertaining to the test on the moderating influence of entrepreneurship on the preference for R&D plus deduction and firm TFP are presented in Table. In Column (3) of Table 3, the moderating effect of entrepreneurship disparities on the magnitude of R&D plus deduction incentives is examined. The coefficients of Ce and tax demonstrate a significant positive association at the 1% level. This signifies that entrepreneurship reinforces the favorable impact of R&D plus deduction intensity on enterprise TFP. Moreover, the positive influence of entrepreneurship strengthens with an increase in entrepreneurial activity, thereby implying a direct complementary relationship between entrepreneurship and the intensity of R&D add-on deduction. In essence, this complementary association between the innovative spirit of entrepreneurs and firms' commitment to R&D investment enhances firms' TFP. Consequently, this preliminary evidence substantiates H2.

Table 3. Mechanism test

	(1) TFP	(2) TFP	(3) TFP
TAX	0.1970*** (0.0060)	0.1724*** (0.0057)	0.1798*** (0.0058)
Ce			0.5361*** (0.0735)
c_Ce#c_tax			0.1770*** (0.0312)
Constant	4.2681*** (0.0526)	4.3068*** (0.0690)	4.3262*** (0.0689)
Controls	No	Yes	Yes
Firms	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	9,226	9,226	9,226
R-squared	0.4015	0.4791	0.4828

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

4.3. Heterogeneity test

4.3.1. Enterprise size

In order to examine the variations in the impact of the R&D expense deduction policy preference on firms' total factor productivity (TFP) across firms of varying sizes, this study employs a split-sample analysis. Specifically, it categorizes firms based on their total assets, wherein those exceeding the sample median after applying the natural logarithm are classified as large firms, while those falling below the sample median are considered small and medium-sized enterprises (SMEs). To estimate the effects, the researchers utilized the benchmark model and present the corresponding findings in columns (1) and (2) of Table 4.

The regression results reveal that the coefficient associated with the intensity of the R&D cost-plus deduction policy is 0.147 for the group of SMEs, which is greater than the coefficient of 0.127 observed for the large enterprises group. Furthermore, this coefficient is statistically significant at the 1% level of significance. These findings suggest that the impact of the R&D expense-plus-deduction policy on enhancing firms' TFP is more pronounced among smaller enterprises. In summary, the outcomes of this study lend support to hypothesis 3a, indicating that the effects of the R&D expense-plus-deduction policy on TFP enhancement differ across enterprises of different sizes.

4.3.2. Differences in business ownership

In order to examine the variations in the impact of the R&D expense deduction policy on the total factor productivity (TFP) of enterprises with different property rights, this study employs a split-sample test and utilizes a benchmark model for estimation. The specific findings are presented in columns (3) and (4) of Table 4. The regression results reveal that the influence of the R&D add-on policy on the TFP of firms does not exhibit significant disparities between state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs). Nevertheless, based solely on the regression outcomes, the motivating effect of the R&D add-on policy appears to be slightly weaker for SOEs compared to non-SOEs. This observation primarily stems from the fact that, following the rapid growth of China's economy, firms have generally recognized the significance of engaging in R&D activities to enhance their core competitiveness, thereby demonstrating greater motivation towards government-driven policies in this domain.

To summarize, this study essentially confirms hypothesis H3b, which suggests variations in the intensity of preferential treatment provided by the R&D expense deduction policy towards promoting the high-quality development of enterprises with distinct property rights.

Table 4. Test results of heterogeneity between property rights nature and firm size

	(1) Large Companies	(2) Small and medium-sized enterprises	(3) State-owned enterprises	(4) Non-State Owned Enterprises
Tax	0.127*** (0.007)	0.147*** (0.009)	0.162*** (0.010)	0.169*** (0.007)
Constant	5.1126*** (0.1045)	4.1555*** (0.1125)	4.6640*** (0.1802)	4.1659*** (0.0873)
Controls	Yes	Yes	Yes	Yes
Firms	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	4613	4613	2938	6288
R-squared	0.534	0.413	0.4192	0.4718

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

4.3.3. Differences in the degree of financing constraints

To investigate the impact of the intensity of the R&D add-on deduction policy on firms' total factor productivity (TFP) under varying degrees of financial constraints, this study categorizes firms based on their financial constraints, specifically defining those with standardized assets (SA) values above the median as the group facing higher constraints and those below the median as the group facing lower constraints. Separate tests are conducted for each group. The findings reveal that the level of R&D add-on deduction intensity contributes to firms' TFP in both groups. However, due to the inherent challenges in accessing capital faced by the more financially constrained group, the effect of the R&D add-on deduction policy on firms' TFP is more pronounced within this subgroup. Hence, the intensity of the R&D add-on deduction policy exhibits greater significance for the more financially constrained group, exhibiting a considerably larger correlation coefficient than the 0.147 observed for the less financially constrained group. In summary, this study provides empirical support for hypothesis H3c.

4.3.4. The area where the company is located

China, being an expansive nation, exhibits considerable variations in terms of its economic development, societal dynamics, and cultural traditions across different regions. Consequently, the impact of R&D cost-added deduction on enterprise Total Factor Productivity (TFP) varies across these

regions. In accordance with the research conducted by Shen X et al.(2019), the Chinese provinces have been categorized into distinct regions: the eastern region encompasses Beijing, Shanghai, Guangdong, Tianjin, Hebei, Fujian, Liaoning, Jiangsu, Zhejiang, Shandong, and Hainan; the central region includes Heilongjiang, Shanxi, Jilin, Henan, Hubei, Hunan, Anhui, and Jiangxi; and the western region comprises Inner Mongolia, Chongqing, Shaanxi, Ningxia, Sichuan, Yunnan, Gansu, Guangxi, Qinghai, Guizhou, and Xinjiang. To examine the influence of R&D expense add-on deductions on firms' TFP in different regions, this study employs a heterogeneity analysis by segregating Chinese A-share listed manufacturing firms into three groups based on their geographical location: the eastern region, the central region, and the western region. Subsequently, a benchmark model is utilized to estimate the aforementioned impact. The findings, presented in columns (3), (4), and (5) of Table 6, reveal that the effect of R&D add-on deduction preference intensity on firms' TFP is significantly positive at the 1% significance level, regardless of the region. However, upon analyzing the regression coefficients, it is evident that the coefficients of R&D plus deduction preference intensity in the eastern and central regions are notably higher than those in the western region. This discrepancy suggests that the positive impact of R&D plus deduction preference intensity is more pronounced in the central and eastern regions, thus largely affirming H3d.

Table 5. Heterogeneity test of regional nature and financing constraints

	(1) Greater financing constraints	(2) Less financing constraints	(3) East	(4) Middle	(5) West
TAX	0.165*** (0.009)	0.147*** (0.008)	0.176*** (0.007)	0.214*** (0.013)	0.109*** (0.015)
Constant	4.349*** (0.314)	2.905*** (0.833)	3.752*** (0.230)	4.561*** (0.478)	5.322*** (0.875)
Controls	Yes	Yes	Yes	Yes	Yes
Firms	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Observations	4607	4619	6612	1443	1171
R-squared	0.471	0.433	0.490	0.658	0.553

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.4. Robustness Test

4.4.1. Replacement variable regression

(1) Substitution of explanatory variables measurement method

To ensure the robustness of the study results, drawing on Lu and Lian Yujun(2012)[28], the TFP-OP measured by the OP method replaces the TFP-LP measured by the LP method, which is brought into the model as the explanatory variable for regression, and the results of the robustness tests are shown in columns (1)-(2) of Table 7, and the coefficients of the intensity of R&D cost-added deduction preferences are all significantly positive, which is consistent with the previous results and basically verifies H1.

(2) Substitution adjustment variable measurement method

To guarantee the robustness of the research results, drawing on Li Hongbin et al(2009)'s method, the cumulative number of patents granted by each company is used as an indicator of

entrepreneurship (CE2), and the cumulative number of patents granted is the sum of the number of patents granted for inventions, utility models, and designs, and the test results are shown in column (3) of Table 7. From the table, it can be seen that the intensity of the R&D expense deduction preference and its interaction term coefficient are significantly positive, which is consistent with the previous results and basically verifies H2.

2. Instrumental variable regression

Since the dependent variable in this paper is enterprise TFP and the explanatory variable is R&D deduction intensity, both of them are micro-level variables of enterprises. When enterprises invest in R&D, the intensity of the deductions they receive will have a certain impact on the enterprise TFP, but in turn, and conversely, individual enterprise TFP may also have an impact on the intensity of the R&D add-on deductions they enjoy, and there is a two-way causal possibility. Enterprises with higher TFP tend to exhibit stronger innovation and R&D strength, and thus may be more capable

of obtaining higher R&D add-on deduction intensity. In order to guarantee the reliability of the results and address the endogeneity issue, this paper uses instrumental variables for regression. In terms of the selection of instrumental variables, first, referring to Xue Gang et al.[34] and Ying-Ying Xue[35] Second, to avoid possible reverse causality, the lagged period of R&D deduction intensity is chosen as the instrumental variable because the policy of R&D deduction for enterprises tends to be somewhat extended. When an enterprise enjoys the add-on deduction in the previous period, it is still more likely to continue to enjoy the add-on deduction in the current period as long as there is no significant change in the way the enterprise operates. Further referring to Ying-Ying Xue's(2022) s approach, two-stage least squares estimation of instrumental variables (2sls) is used for the regression. Table

7 and the sequel Table 7 report the results of the panel fixed effects regression using the above two types of instrumental variables and employing 2sls. The F-statistics in the first-stage regression results are all greater than 10, indicating the strong explanatory power of the selected instrumental variables. The results of the unidentifiable test as well as the weak instrumental variables test in each of these cases confirm the relevance and validity of the selected instrumental variables. Moreover, the direction and significance of the core explanatory variable, tax, and its interaction term estimates in each column of the results are more consistent with the baseline regression results in Table 2. This result suggests that hypotheses 1 and 2 of this paper still hold significantly after addressing the potential endogeneity issue.

Table 6. Robustness test results

	(1)	(2)	(3)
	TFP-OP	TFP-OP	Ce2
TAX	0.166*** (0.006)	0.174*** (0.006)	0.176*** (0.006)
c_Ce#c_TAX		0.179*** (0.032)	
c_Ce ₂ #c_TAX			0.011*** (0.004)
Constant	4.058*** (0.072)	4.078*** (0.071)	4.147*** (0.118)
Controls	Yes	Yes	Yes
Firms	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	9226	9226	9,226
R-squared	0.455	0.459	0.480
F	471.385	419.055	454.371

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01

Table 7. Endogeneity test results

VARIABLES	(2SLS) ₋₁ (1)	(2SLS) ₋₂ (2)	(2SLS) ₋₁ (3)	(2SLS) ₋₂ (4)
L.Tax			0.5402*** (0.0100)	
Tax2	0.1909*** (0.0074)			
Tax		0.2661*** (0.0207)		0.2286*** (0.0115)
Controls	Yes	Yes	Yes	Yes
Firms	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	9,226	9,226	7,908	7,908
R-squared		0.4763		0.5072
F	660.33	449.0	2889.19	361.6

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Continued Table 7 Endogeneity test results

VARIABLES	(2SLS ₋₁) (1)	(2SLS) ₋₂ (2)	(2SLS ₋₁) (3)	(2SLS) ₋₂ (4)
L.Tax			0.9349*** (0.0043)	
Tax2	0.6651*** (0.0108)			
Tax		0.3632*** (0.0307)		0.2366*** (0.0120)
c_Ce#c_tax		0.0419*** (0.0067)		0.0196*** (0.0045)
Controls	Yes	Yes	Yes	Yes
Firms	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	9,226	9,226	7,908	7,908
R-squared		0.4111		0.4290
F	332.05	383.7	2697.80	335.6

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

5. Research Conclusions and Recommendations

5.1. Research findings

Drawing upon a comprehensive dataset encompassing 9,226 observations of A-share listed manufacturing companies spanning the period from 2016 to 2021, this empirical investigation scrutinizes the incentivizing impact of China's R&D cost-plus deduction policy on firms' Total Factor Productivity (TFP). Furthermore, this study endeavors to explore the involvement of entrepreneurship in this process. The findings of this research reveal that the magnitude of R&D deduction (tax) exhibits a significant positive incentive effect on TFP, thereby signifying that a higher percentage of deduction serves as a catalyst for increased R&D investments by enterprises. Consequently, this engenders technological advancement, enhanced productivity, and ultimately, facilitates economic growth. Simultaneously, the study unearths the constructive role played by entrepreneurship in modulating the influence of R&D deduction intensity on TFP. In essence, entrepreneurship enhances the incentive effect of R&D deduction intensity on TFP. This discovery underscores the criticality of entrepreneurship in fostering innovation and R&D within enterprises. Entrepreneurs wield the capacity to stimulate knowledge spillover effects by synergizing production factors and resources, thereby amplifying enterprise TFP. Moreover, entrepreneurship facilitates the translation of R&D outcomes, forges a closer nexus between knowledge innovation and technological innovation, and assumes a decisive role in the redistribution of resources within a market economy. In terms of robustness testing, this study also undertakes alternative measurements for both entrepreneurship and TFP. Encouragingly, the results remain steadfast and reinforce the veracity and reliability of the research outcomes. In sum, the findings of this study underscore the crucial role played by the R&D expense deduction policy in incentivizing corporate TFP, while also highlighting the affirmative moderating role of entrepreneurship in the relationship between R&D expense

deduction intensity and TFP. These findings furnish valuable insights for policymakers and corporate managers alike.

5.2. Countermeasures and suggestions

Based on the aforementioned research findings, the following recommendations are proposed to effectively leverage the incentive mechanism of the R&D add-on deduction policy in enhancing enterprise Total Factor Productivity (TFP):

1. Enhance tax incentives for enterprise R&D activities

The deduction policy for R&D expenses serves as a catalyst for increased investment in research and development by enterprises, thereby fostering technological advancements that contribute to improved TFP. The magnitude of this promotion effect is evidently correlated with the percentage of deductions. Since the inception of the add-on deduction policy, the Chinese government has incrementally adjusted the deduction percentage, from 50% in 1996 to 75% in 2017 for small and medium-sized technology enterprises, extending to non-restricted enterprises in 2018, and further increasing to 100% in 2021 and 2022 for small and medium-sized technology enterprises and manufacturing industries. Consequently, the government should contemplate extending the 100% bonus deduction ratio to encompass all industries. Furthermore, it should consider further enhancing the deduction policy for areas of national importance, such as basic research and original innovation.

2. Optimize the policy design of R&D expense deduction

Given that the impact of the R&D expense deduction policy on enhancing enterprise TFP varies among enterprises with diverse characteristics, it is essential to adopt more precise and targeted preferential policies. For instance, augmenting the intensity of R&D expense deduction for small and medium-sized enterprises, enterprises situated in the western region, and other identified segments can effectively leverage the policy's impact on structural tax reduction, thereby assisting enterprises in attaining high-quality development.

3. Proactively harness the regulatory role of entrepreneurship

Business inputs are intricately linked to the efficiency of factor allocation and the overall quality of a country's economic development. To this end, the government can take several measures. Firstly, it can increase subsidies for enterprise innovation and R&D patents to narrow the compensation gap between innovative and non-innovative activities, thereby modifying the existing compensation structure of enterprise activities and incentivizing enterprises to engage in innovative endeavors. Secondly, by fully leveraging the potential of entrepreneurship, the government should actively guide public opinion, cultivate a favorable environment for innovation and entrepreneurship, and enhance the social status of entrepreneurs. This will foster a virtuous cycle of mutual promotion between entrepreneurship and corporate TFP.

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