Research on the Impact of R&D Expense Deduction Policy on Human Capital Structure of Manufacturing Enterprises

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Abstract: In the current tax incentive landscape, the accelerated depreciation of R&D expenses stands as a paramount policy tool in boosting manufacturing firms' investment in human capital. This study employs a sample of Chinese A-share manufacturing listed companies from 2013 to 2022, treating the 2018 R&D expense deduction policy as an exogenous shock. The analysis initiates with a common trend test, followed by adifference-in-differences (DiD) model for the main effect regression, focusing on the mediating role of R&D expenditure in the policy's impact on the firm's human capital structure.

***Keywords*:** tax incentives, manufacturing firms, human capital structure, difference-in-differences (did) model

1. Introduction

Currently, Chinese manufacturing enterprises are experiencing a slowdown in growth and face issues such as the need for further optimization of their internal human capital structures. To address this situation, tax incentive measures such as additional deductions for R&D expenses can be implemented. By reviewing relevant domestic and international literature, a majority of scholars, such as Ma Fan (2023)[1], argue that the policy of additional deductions for R&D expenses is a special provision established by the government aimed at encouraging companies to increase their investment in R&D and support technological innovation. Studies by Guceril et al. (2019)[2] indicate that when companies benefit from tax reduction incentives, their investment behavior is significantly stimulated. Many scholars concur with the notion that this policy has an incentive effect on corporate R&D investment. However, existing research primarily focuses on how policies such as accelerated depreciation affect the human capital composition of related enterprises in China, with limited attention given to the impact of such policies on the human capital structure of these firms.

Therefore, this paper will focus on addressing the following three questions: "Does the tax policy based on additional deductions for R&D expenses influence the human capital structure of manufacturing enterprises?"; "In the process of this tax policy influencing the human capital structure of manufacturing enterprises, does the variable of R&D investment play a mediating role?"; "Do characteristics such as company size, ownership nature, and asset intensity exhibit heterogeneous effects?"

2. Research hypotheses

Duguet (2012)[3]found that additional deductions for R&D expenses can compensate for the costs of hiring high-skilled talent, further incentivizing increased R&D investment and encouraging companies to hire more high-tech R&D personnel. Dai Tianxi (2022)[4] argues that the manufacturing sector, with its significant tangible assets, requires higher levels of skilled human capital. To achieve competitive advantage through independent R&D innovation, manufacturing firms must employ specialized high-tech talent. Therefore, increasing the R&D deduction for manufacturing firms could indirectly influence their human capital investment behaviors, alleviating conflicts between self-interest and altruism in such investments. This would positively impact the optimization of the human capital structure in manufacturing firms. Thus, this study proposes the following hypothesis:

H1: The policy of adding deductions for R&D expenses has a positive impact on the structure of human capital in manufacturing enterprises.

3. Research design

3.1 Data Sources and Sample Selection

For this study, we selected Chinese A-share listed manufacturing companies from 2013 to 2022. Data was sourced from reputable databases and annual reports. We categorized samples using CSRC criteria and applied exclusion, unit adjustment, and trimming to continuous variables, resulting in 21, 171 valid observations.

3.2 Model Construction

This paper adopts the double-difference model as the main effect model, and takes the 2018 R&D expense deduction policy as an exogenous shock. The details are as follows:

$$Rdr_{it} = \partial_1 + \beta_1 \times Treat_i \times time_i + \gamma_1 \times X_{it} + \xi_{it} \quad (1)$$

In this equation, `Rdr` is a variable used to gauge the structure of human capital; `Treat×time` is a variable used to measure the impact of the additional deduction policy for R&D expenses.

`Treat` is a dummy variable representing whether a company is in the treatment group or not. Based on relevant policy criteria, we identify manufacturing firms not benefiting from the preferential tax treatment and consider them part of the control group, assigning a value of 0. The rest are deemed part of the treatment group and receive the policy benefits, hence assigned a value of 1.

`time` is a dummy variable indicating the period before or after the implementation of the policy. Companies before 2018 are assigned a value of 0, while those after 2018 are given a value of 1.

`X` denotes control variables that could potentially influence the outcome but are not directly affected by the policy.

`i,t` represent the individual company and the corresponding year, respectively.

3.3 Variable Description

3.3.1 Explained Variable

Following the approaches adopted by existing literature, specifically Yuan Dongmei et al. (2021)[5] Zheng Liming et al. (2021)[6], and Dai Tianxi et al. (2022)[4], we define the explained variable as the proportion of highly skilled technical personnel (Rdr) relative to the total number of employees. This metric aims to measure the ratio of highly educated and skilled human capital within the firm. An increase in the proportion of high-skilled human capital under the influence of policy would indicate a positive impact on the firm's human capital structure. Additionally, to ensure robustness, we use the ratio of university graduates to total employees (Medu) as an alternative variable.

3.3.2 Core Explanatory Variable

The interaction term between the policy and time dummy variables is represented as Treat × time. Here, time is a dummy variable indicating the period relative to the implementation of the policy, where it takes the value of 0 for years before 2018 and 1 for years after 2018. Treat is a dummy variable indicating whether a manufacturing firm is affected by the policy, taking the value of 1 if the firm is within the policy's preferential scope and 0 otherwise.

4. Empirical Analysis

4.1 Descriptive stats

The descriptive statistics, as presented in Table 1, indicate that the range of the explained variable, the Human Capital Structure (Rdr), varies significantly among the sample firms. The highest value is 70.100, whereas the lowest is only 0.350, highlighting considerable disparities in human capital structures across the sample firms. The mean value of this variable is 16.477, with a standard deviation of 13.585, suggesting that overall, the human capital structures within the sample firms are at a relatively high level.

Regarding the explanatory variable, the policy shock (Treat×time), the maximum value is 1, and the minimum is 0, indicating a notable difference in the intensity of the policy impact across the sample firms. The mean of this variable is 0.162, with a standard deviation of 0.369, which implies that the level of policy impact is generally low across the firms in the sample.

Table 1. Results of descriptive statistics

	COUNT	MEAN	MIN	SD
Rdr	21171	16.477	0.350	13.585
Medu	21171	29.887	0.000	22.408
Treat× time	21171	0.162	0.000	0.369
Size	21171	22.189	19.887	1.265
Lev	21171	0.397	0.051	0.196
Roa	21171	0.045	-0.235	0.069

	COUNT	MEAN	MIN	SD
Growth	21171	0.182	-0.540	0.376
Board	21171	2.105	1.609	0.197
Indep	21171	0.378	0.333	0.054
Top1	21171	0.331	0.086	0. 144

Notes:*,**,*** indicates significance levels of 10 percent, 5 percent and 1 percent, respectively. (Not to be repeated below)

4.2 Parallel trends test

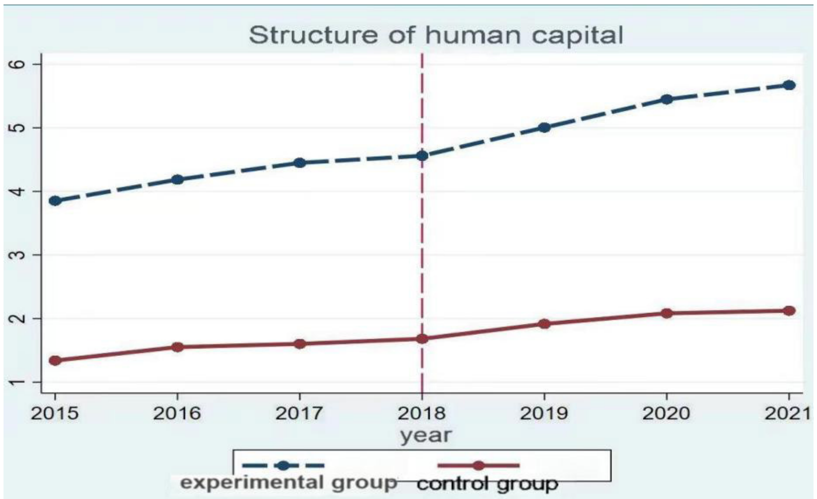

Figure 1. Parallel trend test

As depicted in Figure 1, prior to 2018, there was a consistent growth trajectory observed in both the experimental and control groups. Post 2018, both groups continued to exhibit growth trends, albeit with the experimental group showing a more pronounced increase in growth rates. This could be attributed to the policy implemented by the government in 2018, which provided a 75% deduction on research and development expenses for all manufacturing firms, except those on the negative list. This policy significantly elevated the aspirations of related manufacturing firms to capitalize on the policy benefits, encouraging them to increase their spending on R&D. This, in turn, fostered greater innovation and core competitiveness within the firms, ultimately leading to a positive impact on the structure of human capital.

4.3 Hypothetical regression analysis

From Table 2, result (1) reveals that the coefficient of the policy shock on the human capital structure is 0.8840, a positive number, and statistically significant at the 1% level. This indicates that the policy shock in 2018 had a certain positive impact on the human capital structure of manufacturing firms ($\beta=0.8840$, $p<0.01$). Result (2) shows that the coefficient of the policy shock on the human capital structure is 0.4512, also significantly positive at the 1% level. This further suggests that the human capital structure of manufacturing firms experienced a noticeable positive change under the effect of the policy implemented in 2018. Therefore, hypothesis H1 is supported.

Table 2. Baseline empirical results

	(1) *Rdr*	(2) *Rdr*
Treat× time	0.8840*** (6.4768)	0.4512*** (3.2212)
Size		1.1622*** (11.2152)
Lev		-2.5091*** (-5.3776)
Roa		-2.6770*** (-3.4487)
Growth		-0.3048*** (-2.9699)
Board		-0.3785 (-0.7892)

	(1) Rdr	(2) Rdr
Indep		0.8814 (0.6058)
Top1		-4.0392*** (-5.0049)
_cons	16.3336*** (420.9095)	-6.4115** (-2.4118)
N	21171	21171
adj. R^2	0.242	0.228

4.4 Robustness testing

Due to potential issues such as omitted variable bias, this paper employs alternative dependent variables to test the robustness of the main regression model. Inspired by Liu Qirun et al.'s (2020)[7] method of substituting Medu for Rdr, the paper conducts regression analysis to obtain results (3) and (4) as replacements for results (1) and (2), respectively.

Table 3 reveals that in column (3), the coefficient of the explanatory variable, influenced by the policy shock in 2018, remains positive at 2.6902, and this result is statistically significant at the 1% level. In column (4), the coefficient for the same explanatory variable, still affected by the policy shock in 2018, is also positive at 1.3209, and this result is similarly significant at the 1% level.

These findings confirm that when the dependent variable Rdr is replaced with Medu, the magnitude of the policy shock in 2018's impact on the human capital structure does indeed change. However, the hypothesis that the policy shock in 2018 leads to a positive effect on the human capital structure remains valid. This confirms that the conclusion regarding the positive impact of the additional deduction for R&D expenses on the structure of human capital in enterprises is robust.

Table 3. Regression results with replacement of explanatory variables

	(3)	(4)
	Medu	Medu
Treat×time	2.6902***	1.3209***
	(13.0081)	(6.3238)
Size		3.9729***
		(25.7099)
Lev		-3.3369***
		(-4.7961)
Roa		-3.9954***
		(-3.4518)
Growth		-0.6168***
		(-4.0300)
Board		0.6041
		(0.8448)
Indep		1.7469
		(0.8052)
Top1		-2.4812**
		(-2.0618)
_cons	29.4502***	-57.9756***
	(500.8677)	(-14.6257)
N	21171	21171
adj. R^2	0.233	0.181

4.5 Mechanism of action tests

In order to further explore the manufacturing firms, will they increase their investment in research and development within the firms as a result of the R&D cost deduction policy, so that the human capital structure of the firms will be affected. In this paper, we refer to the method of analysis adopted by Fang Jie et al. (2022)[8], regarding the analysis of mediated utility, and use three-step regression analysis to test the mediated utility. The constructed model is shown below:

$$Rdr_{it} = \partial_1 + \beta_1 \times Treat_i \times time_i + \gamma_1 \times X_{it} + \xi_{it} \quad (2)$$

$$Rd_{it} = \alpha_2 + \beta_2 \times Treat_i \times time_i + \gamma_2 \times X_{it} + \varepsilon_{it} \quad (3)$$

$$Rdr_{it} = \alpha_3 + \beta_3 \times Treat_i \times time_i + \lambda_1 \times Rd + \gamma_3 \times X_{it} + \varepsilon_{it} \quad (4)$$

In equation (2), which aligns with our primary effect regression model, the coefficient β1 of `Treat×time` signifies the impact of the additional deduction for R&D expenses policy on the human capital structure of manufacturing enterprises.

Equation (3) introduces the mediator variable `Rd`, which represents the ratio of R&D expenditures to primary business income of manufacturing enterprises, essentially measuring the intensity of R&D investment. Li Xin et al.'s (2019)[38] study confirmed that the relevant tax regulations on additional deductions for R&D expenses have a positive impact on enhancing the level of corporate R&D investment. They use the ratio of R&D expenses to primary business income as a metric for the scale of R&D investment. A higher ratio indicates a greater impact of these regulations on the human capital structure. If the tax regulation's impact on the human capital structure is mediated by the level of R&D investment, then the coefficient β2 in equation (3) should be positive and statistically significant.

Equation (4) incorporates the `Rd` indicator into equation (1), with the coefficient β3 indicating the direct effect of the additional deduction policy on the human capital structure, while λ1 reflects the effect of R&D intensity `Rd` on the human capital structure after controlling for `Treat×time`. The regression results are shown in Table 4.

Table 4. Intermediation effect regression results

	(5) Rdr	(6) Rd	(7) Rdr
Treat× time	0.4512***	0.1146**	0.3864***
	(3.2212)	(2.0716)	(2.8308)
Rd			0.5676*** (30.0020)
Size	1.1622***	0.5053***	0.8714***
	(11.2152)	(12.3412)	(8.5914)
Lev	-2.5091***	-2.4831***	-1.0585**
	(-5.3776)	(-13.4657)	(-2.3155)
Roa	-2.6770***	-8.9701***	2.4605***
	(-3.4487)	(-29.2262)	(3. 1722)
Growth	-0.3048***	-0.7834***	0.1499
	(-2.9699)	(-19.2993)	(1.4814)
Board	-0.3785	0.0856	-0.4271
	(-0.7892)	(0.4517)	(-0.9142)
Indep	0.8814	0.3438	0.6876
	(0.6058)	(0.5981)	(0.4851)
Top1	-4.0392***	-0.6836**	-3.6628***
	(-5.0049)	(-2. 1441)	(-4.6579)
cons _	-6.4115**	-4.7742***	-3.6315
	(-2.4118)	(-4.5456)	(-1.4013)
N	21171	21169	21169
adj. R^2	0.2282	0.1177	0.1666

Notes:*,**,*** indicates significance levels of 10 percent, 5 percent and 1 percent, respectively.

The regression results in Table 5 reveal that in Column (5), the coefficient β1 for the interaction term is 0.4512, positive, and statistically significant at the 1% level. In Column (6), the coefficient β2 for the interaction term is 0.1146, also positive, and significant at the 5% level, indicating that the tax regulations allowing additional deductions for R&D expenses do enhance the manufacturing firms' investment in R&D. In Column (7), the coefficient β3 for the interaction term is 0.3864, and the coefficient for the R&D intensity Rd is 0.5676, both reaching statistical significance at the 1% level. This suggests that the R&D intensity Rd plays a partial mediating role as an intermediary variable.

The total effect of the additional deduction policy on the human capital structure is 0.4512. The size of the partial mediating effect is 0.065 (0. 1146×0.5676=0.065), accounting for 14.4% (0. 1146×0.5676/0.4512) of the overall effect. This indicates that the scale of R&D investment acts as a partial mediator in the process of the 2018 additional deduction tax rules influencing the human capital structure of manufacturing enterprises.

4.6 Heterogeneity analysis

4.6.1 Heterogeneity analysis of the nature of property rights

Given that non-state-owned enterprises aim for maximizing shareholder interests, they are more inclined to benefit politically from the additional deduction for R&D expenses. On one hand, this can reduce operational costs for the company and lower management risks. On the other hand, it can also improve the company's human capital structure, leading to higher returns. This highlights that manufacturing enterprises with different forms of ownership will be impacted differently by policy shocks.

As shown in Column (8) of Table 6, which represents state-owned manufacturing enterprises, and Column (9), which represents non-state-owned manufacturing enterprises, both columns show positive interaction term coefficients. However, only the coefficient β in result (8) is statistically significant at the 5% level. The coefficient in result (9) is not significant. This suggests that compared to state-owned manufacturing enterprises, the positive promotion effect of the policy shock in 2018 on the human capital structure of non-state-owned manufacturing enterprises is more pronounced.

Table 5. Heterogeneous results on the nature of property rights

	(8) Non-state enterprise	(9) State enterprise
	Rdr	Rdr
Treat×time	0.6153**	0.2588
	(2.5169)	(1.4874)
Size	1.3453***	0.9879***
	(5.9128)	(8.0541)
Lev	-7.1736***	-1.5354***
	(-6.6661)	(-2.9010)
Roa	-2.1915	-2.9916***
	(-1.1437)	(-3.4634)
Growth	-0.4343**	-0.2511**
	(-2.1204)	(-2.1047)
Board	-0.0072	-0.1520
	(-0.0079)	(-0.2633)
Indep	0.1483	2.0858
	(0.0592)	(1.1470)
Top1	-0.1462	-6.6512***
	(-0.1003)	(-6.3550)
_cons	-14.3964***	-1.6076
	(-2.5803)	(-0.5064)
N	5572	15599
adj. R^2	0.226	0.243

4.6.2 Heterogeneity analysis of firm size

Building on the methodology proposed by Liang Fushan and Wang Xijie (2023)[10], the enterprises were categorized based on their industry's average size. As detailed in Column (10) of Table 7, which focuses on small-scale manufacturing enterprises, and Column (11), which pertains to large-scale manufacturing enterprises, the results indicate that the coefficient of the policy shock in 2018, represented by the interaction term `Treat × time`, is 0.4488. This variable is found to be statistically significant at the 5% level. This finding suggests that the policy shock in 2018 was effective in enhancing the human capital structure of small-scale manufacturing enterprises.

Table 6. Heterogeneity of firm size results

	(10) Microenterprise	(11) Large enterprise
	Rdr	Rdr
Treat×time	0.4488**	0.2192
	(2.4479)	(1.0226)
Size	1.2892***	1.7162***
	(7.3792)	(9.1418)
Lev	-3.6832***	-1.7118***
	(-4.6257)	(-2.7008)
Roa	-2.2726*	-3.9826***
	(-1.8815)	(-3.9203)
Growth	-0.3177**	-0.0777
	(-2.3324)	(-0.5092)
Board	-0.5764	-0.7686
	(-0.9029)	(-1.1001)
Indep	1.9956	-0.9911
	(1.0406)	(-0.4649)
Top1	-3.5418***	-3.4132***
	(-3.1328)	(-2.5898)
_cons	-12.6544***	-14.2133***
	(-2.8920)	(-3.1112)
N	9292	11879
adj. R^2	0.124	0.129

4.6.3 Heterogeneity analysis of asset intensity

Cao Zhi and Wu Fei (2023)[11] argue that the selection of the top ten shareholders’ holdings in this study serves as a measure. The rationale behind this choice is that a higher number suggests greater constraints on company managers, enabling them to play a significant role in various critical decisions, including human resource decisions. Building on this premise, the study sets the average of this metric as a benchmark. Enterprises above this average are considered to have a higher asset concentration, while those below it are deemed to have a lower asset concentration.

Analyzing the results in the table, result (12) shows that the coefficient for the policy shock in 2018, denoted by the interaction term `Treat ×time`, is 0.6453. This variable is statistically significant at the 1% level. This indicates that the policy shock in 2018 was effective in enhancing the human capital structure of manufacturing enterprises with a higher asset concentration. This suggests that manufacturing enterprises with a higher level of asset concentration require a complementary higher level of human capital structure.

Table 7. Heterogeneity of firm size results

	(12) High density	(13) Low density
	Rdr	Rdr
Treat×time	0.6453***	0.3893**
	(3.0977)	(2.0246)
Size	1.2120***	1.0766***
	(7.8773)	(6.1601)
Lev	-2.1427***	-3.0605***
	(-3.4111)	(-3.9212)
Roa	-3.5614***	-3.1301**

	(12) High density	(13) Low density
	Rdr	Rdr
	(-3.5821)	(-2.3933)
Growth	-0.2497*	-0.3424**
	(-1.7804)	(-2.2723)
Board	0.6145	-1.9500***
	(0.9253)	(-2.6485)
Indep	5.5864***	-6.8544***
	(2.7468)	(-3.1692)
Top1	-1.5296	-3.8138***
	(-0.8272)	(-2.6012)
_cons	-10.8376***	0.3453
	(-2.7688)	(0.0773)
N	11754	9417
adj. R^2	0.148	0.138

5. Conclusions and recommendations of the study

5.1 Conclusions of the study

This study employs the policy of additional deductions for R&D expenses introduced in 2018 as an exogenous shock, utilizing data from Chinese A-share manufacturing listed companies from 2013 to 2022. By applying the Difference-in-Differences (DiD) method, we investigate the impact of this tax incentive policy on the human capital structure of manufacturing firms. Our analysis yields the following insights:

Firstly, the implementation of the R&D expenses deduction policy in 2018 notably improves the human capital structure of manufacturing firms included in the eligibility list, generating a positive impact on their human capital composition. After substituting the dependent variable and validating the parallel trend, our findings remain robust. This policy, by reducing the tax base for R&D expenses, aims to encourage firms to increase their R&D investments. This necessitates firms to enhance their human capital in terms of talent, infrastructure, and cultural values, thereby influencing their human capital strategies and promoting continuous optimization of the internal human capital structure.

Secondly, in the mechanism examination, we apply a three-step regression analysis, focusing on the ratio of R&D expenditure to primary business income of manufacturing firms and an intermediary variable Rd representing the intensity of R&D investment. This demonstrates that the scale of R&D investment plays a partial mediating role in the process where the tax regulations on additional deductions for R&D expenses in 2018 affect the human capital structure of manufacturing firms.

Lastly, for manufacturing firms with a high level of asset concentration, having a complementary high-level human capital is essential. Thus, they stand to benefit more from the continuous improvement of the R&D expense deduction system. Non-state-owned manufacturing firms, confronted with increasingly fierce market competition, could suffer from loss of market position and commercial opportunities if they lack technological or innovative advancements. Consequently, non-state-owned firms are more inclined to utilize the benefits of the R&D expense deduction policy to reduce operational costs and enhance their appeal to high-tech and high-education talents. Small-scale manufacturing firms, lacking funds and constrained by financing, have a higher demand for R&D expense deductions due to these financial challenges.

5.2 Related Recommendations

For policymakers, when designing policies for additional deductions on R&D expenses, it's crucial to incentivize and guide enterprises that rely more on self-capacity, particularly those owned by non-state entities, focusing on attracting and nurturing high-skilled and high-education talent. They should also intensify support for private enterprises by broadening the scope of eligible companies under the access list, lowering the threshold for tax incentives, and increasing subsidies. This will motivate firms to improve their human capital structures.

For financially constrained firms, most of which are labor-intensive, characterized by low added value, low human capital, and weak market competitiveness, appropriate tax incentives should be established to facilitate their transition from labor-intensive to capital-and-technology-intensive enterprises. Policies should be designed to boost R&D spending and provide additional benefits to support real economy-focused manufacturing sectors. The authorities should also strengthen internal oversight, ensuring the effective implementation of tax incentives, and build a sustainable evaluation mechanism.

For businesses, all types of enterprises should prioritize investments in human capital, recognizing the pivotal role of high-quality, high-skilled talent in fostering innovation. Hiring professionals with advanced degrees and specialized skills, particularly those with multifaceted capabilities, should be prioritized. These firms should encourage employees to pursue professional certifications relevant to their roles. Establishing teams that combine theoretical knowledge with practical skills is particularly important for meeting R&D demands. Collaborating with universities to set up research labs and platforms can help in bridging the gap between academic research and industrial application, facilitating the transformation and upgrading of enterprises.

For state-owned enterprises and those with concentrated capital, efforts should be made to enhance human capital structures through measures like increasing employee mobility and creating favorable working environments. Companies should collaborate with universities to tailor high-skilled, high-education talent development programs that align with their needs and institutional objectives. Offering internship opportunities to students can help prepare them for future employment, ensuring they are familiar with the business processes of the enterprise before entering the job market.

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