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The Impact of Financing Structure on Innovation: Empirical Evidence from Chinese Firms

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Abstract: Selecting an appropriate financing structure is vital to support corporate R&D activities, which is crucial for firms' competitive advantages. So how does financing structure affect innovation? This paper investigates the impact of external financing ratios on corporate R&D. The study finds that a high proportion of external financing suppresses R&D investment. Internal financing and equity financing significantly promote corporate R&D investment, whereas debt financing and government subsidies have a notable inhibitory effect. The presence of equity concentration and financing constraints weakens the suppressive impact of external financing on R&D investment. The inhibitory effect of external financing on R&D intensity is more pronounced in state-owned, small-scale, and traditional enterprises. This paper delves into the optimal financing structure for corporate innovation, providing new perspectives on the relationship between financing structures and corporate R&D, and offering empirical evidence to support the improvement of the equity financing market in the country.

Keywords: External Financing, Corporate R&D, Financing Methods, Hybrid Financing.

1. Introduction

The significance of financial support in fostering technological innovation and industrial development is undeniable [1]. The Chinese government has implemented a series of policies and regulations to promote technological innovation among enterprises, particularly non-financial publicly listed companies. For instance, the "Three-Year Action Plan for Reforming the Science and Technology System" (2021-2023) explicitly calls for increased R&D investment and encourages firms to optimize their financing structures to support innovative projects. Corporate R&D activities often require substantial financial resources, making the choice of an appropriate financing structure particularly crucial.

This paper uses the proportion of external financing as a proxy for corporate financing structure. Using data from non-financial publicly listed companies on the Shanghai and Shenzhen Stock Exchanges from 2008 to 2022, it explores the impact of external financing on R&D investment intensity and its variation across organizational types. The findings indicate that increased external financing reduces R&D investment intensity. Internal and equity financing positively influence R&D intensity, with equity financing having a stronger effect. Conversely, debt financing and government subsidies inhibit R&D investment, with subsidies having a more significant effect. Equity concentration and financing constraints mitigate the negative impact of external financing on R&D

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investment. The effect of external financing is more pronounced in state-owned, small-scale, and traditional enterprises. These results are robust across various checks.

The findings of this study provide new evidence on the impact of financing structure on corporate innovation, verifying the heterogeneity among different types of firms and further demonstrating the crucial role of financial markets in supporting real economic innovation. This research reveals how external financing specifically affects corporate R&D investment, enriching existing studies by analyzing the influence of factors such as equity concentration, financing constraints, and industry type. It offers strong empirical support for financial markets to better serve the innovation needs of the real economy.

2. Literature review and hypothesis development

2.1. Literature review

The financing structure significantly influences corporate R&D investment, with varied impacts from different financing methods. External financing, particularly venture capital, promotes R&D innovation by providing necessary funding and oversight. Internal financing, due to its stability and minimal external oversight, is generally more conducive to continuous innovation, resulting in better innovation performance compared to companies relying on external financing [2]. Debt financing, however, may inhibit R&D investment due to its demand for stable cash flows, limiting investment in high-risk projects [3].

Meanwhile, domestic studies offer mixed conclusions. Government subsidies also play a crucial role in moderating the relationship between debt financing and corporate innovation. Jiang et al highlighted the significant impact of bank loans on R&D investment [4], while Mazzucato and Semieniuk noted that internal and equity financing provide stable R&D funding, business guidance, and market access for private enterprises, whereas debt financing inhibits R&D due to cash flow stability and repayment pressures [5].

Existing literature often focuses on the independent effects of different financing methods, overlooking the mixed financing structures in actual operations. There is a lack of detailed discussion on mixed financing structures and their impact on R&D investment. Additionally, the inconsistent conclusions regarding debt and equity financing's impact on corporate innovation necessitate further empirical analysis. Current research also inadequately considers the heterogeneity in the effects of financing methods on corporate R&D investment, particularly the influence of firm size and industry type.

2.2. Hypothesis development

2.2.1. The Impact of Financing Structure on Corporate R&D

Modern financial theory suggests that increased external financing leads firms to assume higher risks by enhancing investment capacity, enabling engagement in high-risk, high-reward projects with uncertain returns [6]. Debt financing, requiring regular principal and interest payments, can heighten financial pressure during economic downturns or poor performance periods, increasing bankruptcy risk [7].

In contrast, internal financing, such as retained earnings, better supports R&D activities by reducing credit review stringency and repayment constraints, offering greater flexibility [8]. Firms relying on internal funds are more likely to invest in high-risk R&D projects as they are not subject to external creditors' preferences. And when external financing proportion is high, firms have less freedom in innovation investment, especially during economic turmoil, leading to R&D expenditure cuts to mitigate liquidity risks and credit tightening. Caggese and Cuñat found that firms with high

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external financing proportions experienced significant reductions in innovation activities during economic downturns [9]. Thus, we propose the following hypotheses:

H1: *A high proportion of external financing has an inhibitory effect on R&D.*

Analyzing various financing methods, internal and equity financing generally promote corporate innovation investment due to higher flexibility and lower external regulatory pressure, enabling long-term, high-risk R&D projects [10]. Internal financing, through reinvesting a firm's own funds, avoids external market constraints, providing greater freedom for innovation. Equity financing disperses risk by introducing new shareholders who typically support innovative projects for higher returns [11].

In contrast, debt financing may inhibit innovation due to stringent financial constraints and repayment pressures, limiting spending on uncertain innovation activities [12]. The obligation to repay debt can lead to more conservative investment decisions, reducing high-risk, high-reward project funding [13]. Government subsidies, while providing financial support, may lower innovation incentives due to bureaucratic processes and usage restrictions [14]. These subsidies often require firms to meet specific conditions and come with earmarked funding, limiting flexibility and motivation for innovation [15]. In summary, we propose the following hypotheses:

H2: *Internal financing and equity financing have a promoting effect on R&D, while debt financing and government subsidies have an inhibitory effect on the intensity of corporate R&D investment.*

3. Research Design

3.1. Data Sources and Sample Construction

This study uses data from all non-financial A-share listed companies on the Shanghai and Shenzhen Stock Exchanges from 2008 to 2022 as the sample (with the base period t ranging from 2009 to 2021). The rationale for selecting this timeframe is as follows: (1) Some variables involve data from period t-1, and subsequent robustness tests require the exclusion of the pandemic years 2020-2022. To ensure a ten-year data length, the timeframe was set from 2008 to 2022; (2) The financial statements of financial listed companies differ significantly from those of non-financial firms and are thus not comparable.

The data on listed companies were obtained from the CSMAR database and were filtered according to the following criteria: (1) Excluding financial listed companies; (2) Excluding companies with an asset-liability ratio greater than 1. After processing, the study sample comprises 9,070 observations.

3.2. Variable measurement

3.2.1. Dependent variable

In existing research, corporate innovation is typically analyzed from two perspectives: innovation input and innovation output. Specific indicators include R&D expenditure, R&D intensity, the number of invention patent applications, and new product sales. Given that the financing structure first affects a firm's capital composition and subsequently its level of innovation investment, this study adopts its intensity (R&DI) as a measure of corporate innovation, defined as the natural logarithm of the firm's R&D expenditure [16].

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3.2.2. Independent variables

The financing structure mainly consists of internal and external financing. Internal financing (Inte) primarily refers to funds generated from the firm's operations, such as retained earnings. External financing (Exte) involves securing capital through market mechanisms, including debt financing (Debt), equity financing(Equi), and government subsidies(Gove) [17].

However, evaluating a firm's financing structure solely based on the presence or absence of internal and external financing does not fully capture the complexity of its capital composition [18]. Therefore, to analyze corporate financing structures more comprehensively, this study constructs the "proportion of external financing" indicator (Pext), measuring the share of external financing in total financing. Specifically, the proportion of external financing is calculated as follows:

$$Pext_t = \frac{Debt_t + Equi_t + Gove_t}{Debt_t + Equi_t + Gove_t + Inte_t} \tag{1}$$

Where,

$$Inte_t = \frac{1}{Total\ Assets_{t\text{-}1}}(Retained\ Earnings_{t\text{-}1} + Depreciation\ of\ Fixed\ Assets_t + Amortization\ of\ Intangible\ Assets\ and\ Longterm\ Deferred\ Expense_t + Dividends_t + Interest_t) \tag{2}$$

$$Debt_t = \frac{Short\ Loans_t + Long\ Loans_t + Bonds\ Payable_t}{Total\ Assets_t} \tag{3}$$

$$Equi_t = \frac{Equity_{t-1} + Capital\ Reserve_{t-1} - (Equity_{t-2} + Capital\ Reserve_{t-2})}{Total\ Assets_{t-1}} \tag{4}$$

$$Gove_t = \frac{Government\ Subsidies_t}{Total\ Assets_{t-1}} \tag{5}$$

3.2.3. Control variables

Corporate R&D may be influenced by various factors. To effectively identify the impact of financing structure on corporate innovation, as shown in Table1, this study selects control variables on managerial, operational, and profitability indicators.

Table 1: Variable Definitions

Variable type	Variable name	Definition
Dependent variable	R&D intensity(R&D)	Natural logarithm of R&D investment
Independent variables	Proportion of external financing(Pext)	See formula (1)
		Internal financing(Inte) See formula (2)

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Table 1: (continued).

		Debt financing(Debt)	See formula (3)
		Equity financing(Equi)	See formula (4)
		Government subsidies(Gove)	See formula (5)
Managerial indicators	Management Shareholding(Msh)	Proportion of management shareholding	
	Management Compensation(Mco)	Natural logarithm of total management compensation	
	Proportion of Independent Directors(Pid)	Proportion of independent directors on the board	
	Board Size(Bsi)	Total number of directors	
Operational indicators	Tangible Asset Ratio(Tar)	Ratio of tangible assets to total assets	
	Proportion of Fixed Asset Investment(Pfai)	Ratio of net cash proceeds from disposal of fixed assets to total assets	
	Financial Leverage(Lev)	Company's asset-liability ratio	
Profitability indicators	Product Market Competition(Pmc)	Ratio of selling expenses to operating revenue	
	Gross Operating Margin(Gor)	Ratio of gross profit to operating revenue	
	Change in Net Working Capital(Nwc)	Ratio of the increase in net working capital to total assets of the previous period	
	Sales(Sale)	Ratio of operating revenue to total assets of the previous period	
	Sales Growth Rate(Sgr)	Growth rate of operating revenue year-on-year	

3.3. Model

To examine the impact of financing structure on corporate innovation, this study constructs the following model, drawing on the work of Benfratello [19] and Sun and Xiao [20].

$$R\&DI_{it} = \beta_0 + \beta_1 Pext_{it} + \sum_{k=2}^{13} \beta_k X_{it} + d_t + v_i + \mu_{it} \quad (6)$$

In this model, $R\&DI_{it}$represents the dependent variable, measured by the natural logarithm of R&D investment. $Pext_{it}$is the independent variable. X_{it} denotes the 12 control variables used, $d_t$represents time fixed effects, $v_i$indicates individual fixed effects, and μ_{it} is the error term.

3.4. Descriptive Statistics

The results of the descriptive statistical analysis of the variables are shown on the Table 2.

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Table 2: Descriptive Statistics for main variables

Variables	N	Mean	SD	Min	Max
R&D	9070	17.698	1.737	7.170	24.630
Pext	9070	0.655	11.926	-243.878①	1094.392
Msh	9070	0.123	0.195	0.000	2.511
Mco	9070	12.565	0.695	7.998	15.654
Pid	9070	1.272	4.618	-25.000	50.000
Bsi	9070	8.793	1.751	2.000	18.000
Tar	9070	0.926	0.083	0.223	1.000
Pfai	9070	0.003	0.018	-0.007	0.671
Lev	9070	0.453	0.215	0.008	2.861
Pmc	9070	7.025	8.435	0.000	77.151
Gor	9070	0.265	0.170	-0.455	0.970
Nwc	9070	-0.015	1.102	-87.380	19.132
Sale	9070	0.861	5.129	0.022	406.971
Sgr	9070	0.600	21.581	-0.907	1838.372

4. Empirical Results Analysis

4.1. Baseline Regression Results

As shown in Table3, the regression results indicate that the coefficient of the proportion of external financing (Pext) is negative, and its magnitude and significance remain relatively stable after adding control variables. This suggests that the proportion of external financing has an inhibitory effect on R&D investment intensity; specifically, for every standard deviation increase in the proportion of external financing, R&D investment intensity decreases by 0.0012. A higher proportion of external financing increases a firm's debt burden, leading to more funds being allocated to interest and principal repayments, thereby reducing the resources available for R&D and innovation. Additionally, external funds are often accompanied by stricter regulatory and risk-avoidance mechanisms, which may cause firms to reduce investment in high-risk innovation projects when facing debt pressure. Thus, Hypothesis 1 is validated in this study.

Table 3: Regression results of financing structure on corporate innovation

Variables	(1)	(2)	(3)	(4)
Pext	-0.0012***	-0.0012***	-0.0012***	-0.0012***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Managerial indicators	NO	YES	YES	YES
Operational indicators	NO	NO	YES	YES
Profitability indicators	NO	NO	NO	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	9070	9070	9070	9070
Adj_R^2	0.3254	0.3434	0.3463	0.3496

Note: The robust standard errors clustered by firm are reported in parentheses below the coefficients. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, unless otherwise noted.

① When firms engage in large-scale new equity issuance, debt-to-equity swaps, or bankruptcy restructurings, their financial structure undergoes fundamental changes, leading to instances where the proportion of external financing may exhibit negative or extremely high values.

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4.2. Endogeneity Discussions

Different financing structures affect corporate R&D investment, while the specialized assets generated through innovation activities (such as intellectual property) can, in turn, influence a firm's financing structure. Therefore, it is essential to use instrumental variables to eliminate biases arising from endogeneity.

Following Pan et al., this study employs the annual average proportion of external financing and the degree of maturity mismatch from the previous period as instrumental variables [21]. The first estimation, using only the annual average proportion of external financing, yields an F-value of 1625.7, significantly higher than the 10% critical value in the Stock-Yogo weak instrument test, indicating no weak instrument problem. The second estimation, using both instrumental variables, yields an F-value of 791.86, also above the 10% critical value, confirming the robustness of the instruments. The Sargan and Basmann tests, with statistics of 0.8575 and 0.8551 respectively, exceed 0.05, indicating no over-identification problem and validating the instruments' effectiveness. The regression results show that the study's conclusions remain largely unchanged after using these instrumental variables.

Table 4: Regression results of using instrumental variables method

Variables	(1)		(2)	
	First stage	Second stage	First stage	Second stage
Pext		-0.0088**		-0.0088**
		(0.0041)		(0.0041)
Anme	0.8980***		0.8981***	
	(0.1191)		(0.1191)	
$Mismatch_{t-1}$			-0.0079***	
			(0.0020)	
F-statistics	1625.7		791.86	
	(16.38)		(16.38)	
Sargan test X^2-statistics			0.8575	
			(0.3544)	
Basmann test X^2-statistics			0.8551	
			(0.3551)	
Managerial indicators	YES	YES	NO	YES
Operational indicators	YES	YES	NO	YES
Profitability indicators	YES	YES	NO	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	9070	9070	8837	8837

Note: The robust standard errors clustered at the firm level are in parentheses below the coefficients of the three variables, X^2-statistic values are in parentheses with corresponding p-values, and F-statistic values are in parentheses with the 10% critical value of the Stock-Yogo weak IV test.

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5. Further discussion

5.1. Mechanism Analysis

The different financing channels have varying effects on R&D investment intensity. Therefore, firms need to comprehensively consider the mechanisms of each financing channel to choose the financing structure that best supports their long-term development. The mechanism tests for each variable are presented in Table 5.

Table 5: Mechanism analysis results

Variables	Internal financing (Risk) (1)	Debt financing (Mismatch) (2)	Equity financing (Admi) (3)	Gov. subsidies (Cash) (4)
Inte	-2.1341*** (0.0322)			
Debt		-0.4914*** (0.0435)		
Equi			-0.0008* (0.0005)	
Gove				0.1970*** (0.1156)
Managerial indicators	YES	YES	YES	YES
Operational indicators	YES	YES	YES	YES
Profitability indicators	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	9070	9070	8470	9070
Adj_R^2	0.8955	0.1272	0.1012	0.2410

5.1.1. Internal Financing Mechanism

This study uses corporate risk-taking level (Risk) as the mechanism through which internal financing affects R&D investment intensity. Following the methodology in literature, the standard deviation of quarterly adjusted and industry-adjusted return on assets (ROA) for the four quarters of year t is used to measure corporate risk-taking [22]. The specific process is as follows: First, for each quarter of the year, subtract the average quarterly ROA of the firm's industry from the firm's quarterly ROA to obtain the industry-adjusted ROA (formula 8). Next, subtract the industry-adjusted ROA of the same quarter from the previous year from the current year's industry-adjusted ROA to obtain the quarter-adjusted and industry-adjusted ROA (formula 9). Finally, the standard deviation of the quarter-adjusted and industry-adjusted ROA for the year is used to measure the firm's risk-taking level (formula 10).

$$Adj\_Ind\_ROA_{i,q,t} = \frac{NI_{i,q,t}}{Assets_{i,q,t}} - \frac{1}{X}\sum_{k=1}^{X}\frac{NI_{i,q,t}}{Assets_{i,q,t}} \tag{7}$$

$$Adj\_Ind\_S\_ROA_{i,q,t} = Adj\_Ind\_ROA_{i,q,t} - Adj\_Ind\_ROA_{i,q,t-1} \tag{8}$$

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$$Risk_{i,t} = \sqrt{\frac{1}{Q-1}\sum_{q=1}^{Q}(Adj\_Ind\_S\_ROA_{i,q,t} - \frac{1}{Q}\sum_{q=1}^{Q}(Adj\_Ind\_S\_ROA_{i,q,t})^2} \quad (9)$$

The results in column (1) show an estimated coefficient for internal financing of -2.1341, significant at the 1% level, indicating that each percentage point increase in internal financing decreases the firm's risk-taking level by 2.1341 percentage points. This suggests that firms with more internal financing, like retained earnings, can reduce their risk-taking levels by avoiding additional debt burdens and financial risks. Low-risk financing allows for freer decision-making and investment in high-risk, high-return R&D activities, ensuring financial security and continuity in R&D investment, thereby fostering sustained innovation.

5.1.2. Debt Financing Mechanism

This study also examines the impact of debt financing on R&D investment intensity through financing maturity mismatch, measured by the difference in the proportion of short-term debt (Mismatch). Column (2) shows an estimated coefficient for debt financing of -0.4914, significant at the 1% level, indicating that each percentage point increase in debt financing decreases the degree of financing maturity mismatch by 0.4914 percentage points. Clear repayment terms with debt financing allow firms to better align funding needs with debt structure, but lower mismatch and high debt reliance can reduce long-term project investments, like R&D, due to short-term debt repayment pressures. Thus, increased debt financing reduces mismatch, decreasing R&D investment intensity.

5.1.3. Equity Financing Mechanism

Finally, the study uses the administrative expense ratio (Admi) to explore how equity financing promotes R&D investment intensity, with results in column (3). The estimated coefficient for equity financing is -0.0008, significant at the 10% level, indicating that each percentage point increase in equity financing decreases the administrative expense ratio by 0.0008 percentage points. Equity financing avoids the interest payments required by debt financing, reducing financial costs and administrative expenses, allowing savings to be allocated to R&D and innovation. Hence, increased equity financing lowers administrative expenses, increasing R&D investment intensity.

5.1.4. Government Subsidy Mechanism

This study uses corporate cash holdings (Cash) to examine how government subsidies affect R&D investment intensity. The results in column (4) show that the estimated coefficient for government subsidies is 0.1970, significant at the 1% level, indicating that each percentage point increase in government subsidies raises a firm's cash holdings by 0.1970 percentage points.

Government subsidies enhance a firm's cash holdings in several ways. They provide a direct cash inflow without cost, boosting liquidity and alleviating operational funding pressures [23]. Subsidies also signal to the market and investors that the government supports the firm's growth prospects, enhancing credibility and potentially increasing external financing opportunities [24]. Additionally, subsidies often cover specific operating costs, such as innovation expenses, allowing firms to save on these costs and maintain higher cash flow.

However, while increased cash holdings from subsidies can enhance financial flexibility and encourage R&D activities, they may also lead to more conservative investment strategies in the short term, especially during economic uncertainty. This "cash retention effect" means that despite the intent to support R&D, increased cash holdings might reduce R&D investment intensity as firms

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prioritize liquidity and financial security. Thus, an increase in government subsidies raises cash holdings but may paradoxically decrease R&D investment intensity.

5.2. Heterogeneity Analysis

To further analyze the differential impacts of financing structure on R&D investment intensity across firms with different ownership types, sizes, and industry characteristics, this study conducts heterogeneity tests from these three perspectives. Table 6 presents the results of the heterogeneity tests.

Table 6: Heterogeneity analysis results

Variables	Ownership		Size		Industry	
	SOE	Non-SOE	Small	Large	Traditional	High-tech
Pext	-0.0010***	-0.0100	-0.0012***	-0.0750	-0.0010***	-0.0452
	(0.0003)	(0.0137)	(0.0002)	(0.0616)	(0.0003)	(0.0294)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	3609	5461	6349	2721	6528	2542
Adj_R^2	0.3403	0.3682	0.2732	0.3430	0.3356	0.3941

The results indicate that external financing significantly inhibits R&D investment intensity in state-owned enterprises (SOEs) but not in non-state-owned enterprises. SOEs face stricter policy and regulatory constraints, leading to conservative financial behavior and a focus on government-mandated goals over technological innovation. Non-state-owned enterprises, however, have greater flexibility in fund allocation, allowing them to use external financing effectively for R&D.

Regarding firm size, external financing significantly inhibits R&D investment intensity in small-scale enterprises but not in large-scale enterprises. Small firms face higher costs and risks in managing external funds and lack the credit background of larger firms, making them cautious in high-risk R&D activities. Large enterprises, with stable financial conditions and diverse financing channels, can better manage the risks of external financing, rendering its impact on R&D investment insignificant.

In terms of industry characteristics, external financing significantly inhibits R&D investment in traditional firms but not in high-tech firms. Traditional firms, with stable business models and market demands, have less urgent innovation needs, reducing their R&D investment when facing financial burdens. High-tech firms, operating in a competitive and rapidly evolving environment, prioritize R&D investment to maintain technological leadership, despite external financing pressures. Thus, the impact on their R&D investment intensity is insignificant.

6. Robustness Tests

6.1. Controlling for Potential Omitted Variables

To control for potential confounding factors, reduce omitted variable bias, and ensure the robustness of the empirical results, this study includes three additional control variables: selling expenses(Selx), Tobin's Q, and revenue growth rate(Rgr). Columns (1)-(4) in Table 7 present the regression results with progressively added control variables, which are consistent with the baseline regression results, effectively validating the robustness of the baseline regression results.

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Table 7: Robustness test results

Variables	(1) R&DI	(2) R&DI	(3) R&DI	(4) R&DI
Pext	-0.0012***	-0.0012***	-0.0012***	-0.0012***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Selx	NO	YES	YES	YES
Tobin's Q	NO	NO	YES	YES
Rgr	NO	NO	NO	YES
Managerial indicators	YES	YES	YES	YES
Operational indicators	YES	YES	YES	YES
Profitability indicators	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	9070	9070	9070	9070
Adj_R^2	0.3496	0.3515	0.3520	0.3520

6.2. Sub-sample Regressions

6.2.1. Excluding the Impact of Pandemic Years

The pandemic's economic fluctuations and government interventions could impact corporate financing behavior and R&D investment decisions. Economic uncertainty might force firms to reduce or delay R&D projects, while government fiscal policies or subsidies may cause deviations from normal trends. To eliminate these effects, this study excludes the 2020-2022 sample and re-runs the regressions.

6.2.2. Excluding Public Service Enterprises

Public service enterprises, heavily regulated by the government, have financing and investment decisions influenced more by policy directives than market conditions. These firms, providing essential services like water, electricity, transportation, and communications, have unique funding sources, cost structures, and profit models. Therefore, their financing and R&D behavior may not represent typical market-driven practices. This study excludes samples from education, healthcare, cultural arts, sports, and other public service enterprises and re-runs the regressions.

After excluding the 2020-2022 pandemic years and public service enterprises, the regression analysis is conducted again. The results, shown in Table 8, are consistent with the baseline regression conclusions, further validating their robustness.

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Table 8: Robustness test excluding pandemic years and public service enterprises

Variables	PANEL A: Excluding Pandemic Years			
	(1)	(2)	(3)	(4)
Pext	-0.0013***	-0.0012***	-0.0012***	-0.0012***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Managerial indicators	NO	YES	YES	YES
Operational indicators	NO	NO	YES	YES
Profitability indicators	NO	NO	NO	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	8470	8470	8470	8470
Adj_R^2	0.2644	0.2820	0.2857	0.2886
	PANEL B: Excluding Public Service Enterprises			
	(1)	(2)	(3)	(4)
Pext	-0.0013***	-0.0012***	-0.0012***	-0.0012***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Managerial indicators	NO	YES	YES	YES
Operational indicators	NO	NO	YES	YES
Profitability indicators	NO	NO	NO	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	8951	8951	8951	8951
Adj_R^2	0.3255	0.3424	0.3459	0.3495

6.3. Using Different Standard Errors

This study employs various robust standard errors—ordinary robust standard errors, province-level clustered robust standard errors, and industry-level clustered robust standard errors—to further examine the robustness of statistical inferences. Province-level clustering accounts for the socio-economic factors' correlation within larger regions, while industry-level clustering aims to capture the inter-firm correlations within the same industry. Ordinary robust standard errors provide a comparison to test the sensitivity of the results to the clustering method. The results of regressions using different robust standard errors are presented in Table 9. These results are consistent with the baseline regression results, effectively verifying the robustness of the baseline regression results.

Table 9: Robustness test using different robust standard errors

Variables	Ordinary robust SE		Province clustered SE		Industry clustered SE	
	(1)	(2)	(3)	(4)	(5)	(6)
Pext	-0.0013***	-0.0012***	-0.0013***	-0.0012***	-0.0013***	-0.0012***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES

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Table 9: (continued).

Year FE	YES	YES	YES	YES	YES	YES
N	9070	9070	9070	9070	9070	9070
Adj_R^2	0.3254	0.3496	0.3254	0.3496	0.3254	0.3496

7. Conclusions

Corporate R&D innovation serves as a critical factor for maintaining competitiveness and market position. However, R&D activities often require substantial funding. Choosing an appropriate financing structure ensures a stable supply of funds and reduces financial risk, which is crucial for the successful execution of R&D projects.

Existing research typically focuses on the individual financing methods, neglecting the fact that firms often use a combination of financing methods in practice. Based on this, the study constructs a variable for the proportion of external financing and conducts an empirical analysis using data from all non-financial listed companies from 2008 to 2022. The results indicate that a high proportion of external financing has an inhibitory effect on the intensity of corporate R&D investment. Further regression analysis of the components of external financing shows that internal financing and equity financing positively influence R&D investment intensity, with equity financing having a stronger effect. Conversely, debt financing and government subsidies negatively affect R&D investment intensity, with government subsidies having a more pronounced inhibitory effect. The heterogeneity analysis reveals that a high proportion of external financing significantly inhibits R&D investment in state-owned, small-scale, and traditional enterprises. Robustness tests, including adding control variables and sub-sample regressions, confirm the stability of the study's conclusions.

Based on the above analysis, the study's conclusions have several policy implications: First, optimizing corporate financing structure. Encourage firms to balance internal financing and equity financing while reducing reliance on debt financing and government subsidies, particularly supporting R&D innovation in state-owned, small-scale, and traditional enterprises. In addition, developing equity financing markets. Implement preferential policies to reduce the cost of equity financing, increase financing efficiency, and help firms raise funds for long-term innovation projects. What's more, using government subsidies effectively. Optimize the subsidy allocation mechanism to focus on supporting corporate R&D innovation, while enhancing oversight to improve the effectiveness of subsidy use.

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