R&D Roulette: How Betting on Innovation Spins Business Performance

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Abstract. Utilizing data from listed companies spanning the years 2006 to 2022, this paper examines the correlation between R&D investment and corporate performance. It also explores the mechanisms and moderating effects of ownership concentration. R&D investment boosts business performance by alleviating financing constraints and enhancing product competitiveness, influenced by internal control and external governance factors. There are notable differences in the effects based on enterprise scale and type. Consequently, this paper offers policy recommendations to encourage increased R&D investment and to promote performance improvement through robust internal and external governance mechanisms.

Keywords: R&D Investment; Corporate Performance; Financing Constraints; Product Market Competitiveness; Corporate Governance.

1 Introduction

In the context of a booming global economy, technological innovation has become a crucial engine for enterprises to sustain a competitive edge and attain long-term growth. As science and technology continue to advance, the role of enterprises in fostering innovation has become increasingly significant. Technological innovation is not only essential for the success of enterprises but also a decisive force in shaping their future prospects. Continuous investment in R&D and technological updates enables enterprises to adjust constantly evolving market landscape, maintaining competitive flexibility as well as gaining creative advantages[1]. Corporate governance and ownership structures have also evolved to adapt to the complex and dynamic business environment. A highly centralized ownership structure allows enterprises to formulate and implement innovation strategies more swiftly and enhances decision-making efficiency. However, despite the growing interest in the interplay between ownership structure, R&D investment[2], and innovation performance, scholarly research on this relationship remains relatively sparse. Through this research, we can better understand how enterprises achieve business growth and improve performance through innovation activities,

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offering support for managers and helping enterprises maintain a competitive edge in a challenging market environment[3].

2 Literature Review

Some studies have identified a strong positive correlation between R&D investment and firm value, especially in high-tech companies. Research indicates that R&D investment boosts company value, with CEO organizational power positively moderating this relationship. However, due to the distinct characteristics of different industries, there can be a negative correlation between R&D investment and enterprise performance in certain sectors. For example, current R&D investment can increase expenditures and reduce profits, thereby negatively affecting company performance. In technology-intensive industries[4], there is often a significant negative correlation between early-stage R&D investment and company performance, suggesting that R&D capital investment may not yield immediate benefits and can initially harm enterprise performance. Empirical analyses frequently emphasize the lag effect of R&D investment on enterprise performance.

Ownership structure is pivotal in studying enterprise performance, involving the interplay of various factors like ownership concentration, national systems, and internal governance. Ownership concentration is crucial because a highly concentrated ownership structure allows enterprises to implement long-term strategies more effectively, improving innovation and strategic execution. However, the relationship varies across different national systems due to differences in law, systems, and culture, affecting the actual impact of ownership structure on enterprise performance.

Internal governance mechanisms are also important, as the design of equity incentive systems can influence long-term performance by motivating management to align more closely with shareholder interests[5]. Understanding the connection between ownership structure and corporate performance is essential for corporate decision-makers as well as investors, helping them make more accurate strategic planning and investment decisions to achieve better performance.

3 Theoretical Mechanism and Research Hypothesis

3.1 Corporate R&D Investment and Business Performance

The quantity and effectiveness of R&D investment directly impact an enterprise's innovation capability, market competitiveness, and profitability, thereby determining its overall performance. For enterprises, strategically enhancing R&D investment and optimizing R&D management are crucial for achieving sustainable development as well as enhancing performance. R&D investment promotes technological innovation and new product development[6], enabling enterprises to launch competitive products and services that attract more customers and increase market share. Additionally, R&D efforts can optimize production processes, reduce costs, and improve efficiency, leading to higher profit margins and overall performance. Continuous R&D investment allows

enterprises to maintain technological leadership and develop a unique a competitive edge that is challenging for competitors to replicate or exceed[7]. it sustained innovation capability ensures that the company remains at the forefront of the industry, reinforcing its market position and overall performance.

3.2 The Path of Enterprise R&D Investment to Improve Enterprise Performance

Investing in R&D plays a crucial role in alleviating financing constraints and improving performance. By boosting R&D investment, companies can enhance their technological capabilities and market competitiveness. improve their creditworthiness, and enhance their ability to secure financing. This also increases the value of intangible assets, expands market share[8], and attracts investors and financing channels, thereby reducing financing constraints and promoting improved enterprise performance.

For enterprises, strategically increasing R&D investment and enhancing technological innovation capability are essential strategies for mitigating financing constraints and boosting performance. R&D investment not only significantly enhances the market competitiveness of products but also promotes performance improvement by improving product quality, optimizing cost structures, enhancing brand value, and increasing market responsiveness. Therefore, enterprises should prioritize R&D investment and continuously drive technological innovation to achieve long-term stable performance growth and maintain a competitive market advantage[9].

3.3 The Impact of External Mediation and Internal Control on Corporate R&D Investment and Performance

The main shareholders have a greater voice in the decision-making process, which can make decisions quickly and effectively, and reduce the cost of internal coordination and conflict. This will help enterprises to make rapid and consistent decisions on R&D investment and ensure the successful progression of R&D projects. In enterprises with high ownership concentration, The main shareholders typically focus more on the enterprise's operation and management, which allows for more effective supervision and management of R&D activities. This ensures the rational use of R&D funds and the successful implementation of R&D projects, reducing resource waste and management gaps, and enhancing the efficiency and effectiveness of R&D investment. In cases of high ownership concentration, R&D investment can more effectively drive improvements in enterprise performance[10].

High equity concentration thus promotes performance enhancement through increased R&D investment. In businesses with high ownership concentration, major shareholders exert significant influence over decision-making processes. This leads to quick[11] and effective decisions, reducing internal coordination costs and conflicts. As a result, enterprises can swiftly and consistently make decisions regarding R&D investment, ensuring the smooth progress of R&D projects[12]. Major shareholders in such enterprises generally pay closer attention to operations and management, effectively supervising and managing R&D activities[13].

Building on the aforementioned theoretical framework, this study proposes the following hypotheses:

H1: Enterprise R&D investment promotes enterprise performance.

H2: Enterprise R&D investment enhances performance by alleviating financing constraints and improving product market competitiveness.

H3:Under the mediation of internal control and external governance, corporate R&D investment boosts corporate performance.

4 Study Design

4.1 Sample Selection, Data Sources, and Data Processing Procedures

4.1.1 Data Collection.

1 Determine data requirements.

Clarify research objectives: Determine the specific data types required for the study (fiscal revenue, expenditure, budget, debt, etc.), including 4360 listed companies from 2012 to 2022, with a total of 8359 observation results.

2 Data source.

Official government websites: National Bureau of Statistics, Ministry of Finance, and local government websites.

International organizations and databases: IMF, World Bank, OECD.

Academic research and papers: through university libraries and online databases.

4.1.2 Data Cleaning.

1. Data inspection.

Integrity check: Check whether the data is missing or incomplete, and determine the data that needs to be supplemented[14].

Consistency check: Check the consistency of data, such as whether there are conflicts between data from different sources.

2. Data cleaning steps.

(1) Eliminate inactive companies: Excluding companies with transaction status of ST, * ST, and PT this year[15].

(2) Handling missing data: Companies that have been missing key variables for several consecutive years are excluded. Fill in some missing key samples using linear interpolation.

(3) Outlier handling: In order to eliminate errors caused by outliers, the extreme values of enterprise level variables were trimmed by 1%.

4.1.3 Data Standardization.

Unit conversion: Unify data units from different sources (such as converting different currency units to the same currency unit)[16].

Uniform format: Ensure that all data is formatted consistently, facilitating subsequent analysis[17].

4.2 Variable Definitions and Measurements

4.2.1 Dependent Variable.

To analyze enterprise performance, the return on total assets(ROA)is used as the key indicator. ROA clarifies the relationship between an enterprise's resources and revenue, evaluating the ability of enterprises to effectively utilize available assets to generate revenue. Essentially, it measures the efficiency of converting asset investments into profits[18].

4.2.2 Explanatory Variables.

Scientific and technological innovation encompasses multiple aspects, making it an intangible concept without direct measurement standards. This paper employs the input method, focusing on enterprise R&D investment, as a commonly used measurement approach[19].

4.2.3 Control Variables.

Long-term capital debt ratio, equity ratio, equity multiplier, financial leverage, total asset growth rate, enterprise nature, enterprise scale, asset-liability ratio, board size, enterprise age[20].

4.2.4 Mediating Variables.

Product market competitiveness (HHI) is calculated using formula (1).

Financing constraint (SA index) is determined using formula (2).

$$HHI = \sum_{i=1}^{N}(X_i / X)^2 \quad \text{i=1,2, ... N} \tag{1}$$

$$SA *= -0.737 * Size + 0.042 * Size^2 - 0.03 * Age \tag{2}$$

4.2.5 Mediation Variables.

Internal control Ownership concentration is defined as the collective shareholding percentage of the top three shareholders[20].

These sample is divided into two groups: high analyst attention and low analyst attention.

The definitions of the variables are outlined in Table 1:

Table 1. Variable Descriptions

Variable type	Variable name	Variable symbol	Variable definition
Dependent Variable	Return on Total Assets (ROTA)	ROA	Net profit/average annual total assets (%)
Explanatory variable	Research & Development (R&D) investment	R&D	Research & Development (R&D)
Control variable	Long-term capital debt ratio	DLCR	(Total assets at the end of the period - Total assets at the beginning of the period) / Total assets at the beginning of the period
	Equity ratio	DER	Equity ratio =(total liabilities/shareholders'equity)× 100%
	Equity Multiplier	EM1	Equity multiplier = 1/ (1-asset-liability ratio)
	Financial Leverage	DFL	DFL=(EPS/EPS)/(EBIT/EBIT)
	Total asset growth rate	Asset-Growth	Growth rate of total assets =(total assets at the end of the year-total assets atthebeginning of the year)÷ total assets at the beginning of the year × 100%.
	Nature of the enterprise	SOE	A value of 1 for state-owned enterprises and 0 for non-state-owned enterprises
	Enterprise scale	Size	The natural logarithm of total assets
	Asset-liability ratio	LEV	Total liabilities/total assets
	Board size	Board	Number of board members
	Enterprise age	Age	Observation year-establishment year (year)
Mediating variable	Financing Constraints Index	SA	$SA *= -0.737 * Size + 0.042 * Size^2 - 0.03 * Age$
	Product market competitiveness	HHI	The Herfindahl-Hirschman index(HHI)is calculated by taking the reciprocal of a number, as demonstrated in Equation.
Mediation variable	Internal control	OSC	Ownership concentration: the combined shareholding ratio of the top three shareholders
	External governance	AT	The sample is divided into two groups, high and low analyst attention, based on the annual median of the natural logarithm of the number of analysts following.

4.3 Model Development

4.3.1 Baseline Regression Model.

To evaluate the impact of R&D investment on enterprise performance, the following benchmark model is established:

$$\mathrm{ROA}_{it} = \beta_0 + \beta_1 \mathrm{R\&D}_{it} + \beta_2 controls_{it} + u_i + \theta_t + \varepsilon_{it} \quad (3)$$

The control variables. mu_i,theta_t, andepsilon represent province fixed effects, time fixed effects, and random disturbances, respectively. beta andgamma are the regression coefficients for the explanatory and control variables.

4.3.2 Mediation Effect Model.

Mediating Effect Model Setup: To verify that product market competitiveness and financing constraints mediate the relationship between R&D investment and enterprise performance, this paper establishes the following mediating effect model based on formula (3) for analysis:

$$M_{it} = \beta_0 + \theta_1 \mathrm{R\&D}_{it} + \lambda_i + \mu_i + \varepsilon_{it} \tag{4}$$

$$\mathrm{ROA}_{it} = \beta_0 + \beta_1^{'} \mathrm{R\&D}_{it} + \alpha M_{it} + \sum\nolimits_j \gamma_j controls_{jit} + \lambda_i + \mu_i + \varepsilon_{it} \tag{5}$$

Where, M it represents the mediating variable, and the meaning of other variables including product market competitiveness(HHI)and financing constraints(SA)in this paper is the same as that in formula(3). In formula (3), β 1 represents the total effect. If it is significant, verify the influence of R & D investment on the mediating effect through formula (4). If R&D investment is not significant, a complete mediating effect is present. If the coefficient of R&D investment is significant, a partial mediating effect exists.

Where M represents the mediating variable, and the meanings of other variables, including product market competitiveness (HHI) and financing constraints (SA), are the same as in formula (3). In formula (3),beta_1represents the total effect. Ifbeta_1is significant, the influence of R&D investment on the mediating effect is verified through formula (4). Ifthetais significant, R&D investment is added to the regression of formula (5) to test for a complete mediating effect in the mediating variable. If R&D investment is not significant, there is a complete mediating effect. If the coefficient of R&D investment is significant, it indicates a partial mediating effect.

4.3.3 Moderation Effect Model.

Model settings for moderating effects This paper investigates how internal control and external governance moderate the link between R&D investment and corporate performance. Based on formula (3), the moderating effect model is set as follows:

$$\mathrm{ROA}_{it} = \beta_0 + \beta_1 \mathrm{R\&D}_{it} + \beta_2 T_{it} + \beta_3 \mathrm{R\&D}_{it} * T_{it} + \sum\nolimits_j \gamma_j controls_{jit} + \lambda_i + \mu_i + \varepsilon_{it} \tag{6}$$

In this model, internal and external control T as a moderating variable) includes two variables: internal control (MSR) and external governance (AT). The product of R&D investment R&D and the moderating effects of internal control and external governance T is added as a regulatory effect, with other variables set according to formula (3). it indicates a positive moderating effect of the number of independent directors and analysts. If the signs are opposite, it indicates a negative moderating effect.

5 Empirical Analysis

This paper comprehensively analyzes the key variables related to the performance of listed companies. The average return on total assets(ROA)is 0.035, suggesting that the firms in the sample generate a modest net profit per unit of assets on average. However, the high standard deviation of 0.069 indicates significant variability in this indicator, with values ranging from a low of -0.373 to a high of 0.257. This range shows that while some enterprises face serious financial problems, others have achieved substantial profits. TobinQ has a mean of 1.918, a variance of 1.254, a minimum of 0.802, and a maximum of 15.606, The definitions of the variables are outlined in Table 2.

Table 2. Descriptive Statistics

	Mean	Std Dev	Min	Max	N
ROA	0.035	0.069	-0.373	0.257	7101
TobinQ	1.918	1.254	0.802	15.606	7272
R&D	2.78e+08	9.60e+08	0.000	2.20e+10	7359
DLCR	0.1523	0.157	0.000	0.7161	7301
DER	1.227	1.322	0.0538	9.856	7359
EM1	2.227	1.322	1.053	10.856	7359
FL	1.295	1.022	-1.981	11.548	7335
AssetGrowth	0.1500	0.351	-0.382	5.115	7101
SOE	0.427	0.4947	0.000	1.000	7212
Size	22.444	1.278	19.316	26.452	7359
LEV	0.455	0.195	0.051	0.907	7359
Board	2.127	0.200	1.609	2.708	7359
Age	3.040	0.261	1.945	3.610	7359

Regarding R&D, the average R&D investment of enterprises is 278 million yuan, with a standard deviation of 960 million yuan. The values range from a minimum of 0 to a maximum of 22 billion yuan. reflecting the varying levels of innovation activities among enterprises. Other control variables also exhibit diversity. The average long-term capital debt ratio (DLCR) is 0.1523, with a variance of 0.157, a minimum of 0, and a maximum of 0.7161. The equity ratio (DER) has an average of 1.227, a variance of 1.322, a minimum of 0.0538, and a maximum of 9.856.

The equity multiplier (EM1) shows an average of 2.227, a variance of 1.322, a minimum of 1.053, and a maximum of 10.856. Financial leverage (FL) has an average value of 1.295, a variance of 1.022, a minimum of -1.981, and a maximum of 11.548. The total asset growth rate has an average of 0.1500, a variance of 0.351, a minimum of -0.382, and a maximum of 5.115. The average enterprise size is 224.44 million yuan, with a variance of 1.278, a minimum of 193.16 million yuan, and a maximum of 264.52 million yuan.

The asset-liability ratio (LEV) has an average value of 0.455, a variance of 0.195, a minimum of 0.051, and a maximum of 0.907.The average board size is 2.127, with a

variance of 0.200, a minimum of 1.609, and a maximum of 2.708. Finally, the average enterprise age is 3.040, with a variance of 0.261, a minimum of 1.945, and a maximum of 3.610.

5.1 Benchmark Regression Analysis

The regression analysis utilizes least squares, random effect model, and two-way fixed effect model. The results, presented in Table 3, show that enterprise R&D investment significantly enhances performance at the 5% level across all models, The definitions of the variables are outlined in Table 3.

Table 3. Benchmark Regression Results

Enterprise performance	Least Squares Regression		Random effects	Two-way fixed effect
	Without control variable	Including control variables		
R&D	4.10e-12 *** (1.32e-12)	1.76e-12 ** (8.32e-13)	1.61e-12 ** (8.01e-13)	3.25e-12** (1.12e-12)
DLCR		-0.04394*** (0.01012)	-0.044839*** (0.01016)	-0.04734*** (0.0133)
DER		-2.1089** (1.0036)	-1.2456 (1.0127)	-1.4160 (1.0343)
EM1		2.1029** (1.0036)	1.2392 (1.0127)	1.4093 (1.0343)
FL		0.00212*** (0.000576)	0.00222*** (0.00057)	0.00202*** (0.0006)
AssetGrowth		0.04586*** (0.00406)	0.04702*** (0.00413)	0.04251*** (0.0039)
SOE		-0.00298 (0.00277)	0.0003 (0.0026)	-0.00322 (0.0063)
Size		0.01516*** (0.00142)	0.01341*** (0.00136)	0.0133*** (0.00315)
LEV		-0.1281*** (0.01301)	-0.1191*** (0.01265)	-0.12367*** (0.01872)
Board		0.00870 (0.0060)	0.01243** (0.00604)	0.0076 (0.0088)
Age		-0.01546*** (0.00497)	-0.03620*** (0.0045)	-0.04968*** (0.0094)
Constant	0.0467967*** (0.0102637)	-2.2938*** (1.0082)	-1.365 (1.014)	-1.4735*** (1.0458)
N	7101	6897	6897	6897

Note: Robust standard errors are in brackets. *p<0.1, **p<0.05, ***p<0.01. The same applies below.

5.2 Robustness Test

5.2.1 Replace the Dependent Variable.

To ensure robustness, Tobin's Q value is used as an alternative measure of business performance, with the explanatory variables lagged by one or two periods. The robustness test results, presented in Table 4, indicate that R&D investment significantly enhances enterprise performance at the 1% level, confirming the robustness of the findings, The definitions of the variables are outlined in Table 4.

Table 4. Results of Robustness Test

Enterprise performance	Replace the explained variable	Lag by one period	Two lag periods
R&D	5.93e-11 ***	1.44e-11 ***	1.10e-11**
	(2.52e-11)	(3.68e-12)	(2.74e-12)
Lag by one period		1.45e-11***	1.19e-11***
		(4.04e-12)	(3.33e-12)
Two lag periods			
Control variable	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes
Constant	-24.112	-2.946	-3.3565
	(54.675)	(3.2572)	(3.2099)
N	6814	5677	4520

5.2.2 Constructing Tool Variables.

The mitigation model may face endogeneity issues due to missing variables. This is addressed by using the heteroscedasticity construction method for instrumental variables. The basic idea is as follows:

$$Y_2 = X^{'}\alpha + \varepsilon_2 \qquad \varepsilon_2 = U + V_2 \tag{7}$$

$$Y_2 = X^{'}\alpha + \varepsilon_2 \qquad \varepsilon_2 = U + V_2 \tag{8}$$

U is the unobservable factor, and V 1 and V 2 are the heterogeneity errors.In the case that the instrumental variable is hard to find or there is a weak instrumental variable problem, a set of observable exogenous variables Z can be used as the instrumental variable by constructing[Z − E(Z)]ε 2. Here, it is assumed that the exogenous variable Z originates from all the variables at the enterprise level and the time level in the control variable X. The heteroscedastic-based identification method breaks through the restriction that the traditional instrumental variable estimation must satisfy the exclusive constraint condition. The initial stage of estimation involves conducting OLS linear regression on equation(8)to derive the estimated value of the residual term ε 2.Subsequently, the instrumental variable[Z-E(Z)]ε 2 is constructed in the following step .The results are presented in Table 4. 4. The estimation coefficient of the core explanatory variable, R&D investment, is significantly positive. The results of the weak instrumental variable test and the over-identification test confirm the validity of the instrumental

variables. This indicates that the benchmark regression results remain robust even after addressing endogeneity through instrumental variable estimation, The definitions of the variables are outlined in Table 5.

Table 5. OLS test results

Variables	ROA	TobinQ
R & D investment	2.01e-11 *** (2.02e-12)	1.03e-09*** (4.36e-11)
Control variable	Yes	Yes
Time fixed effect	Yes	Yes
Individual fixed effects	Yes	Yes
Constant	0.0299*** (0.001)	2.197*** (0.0222)
K-P LM(P-value)	0.000	0.000
C-D Wald F	1784.556	163.979

5.2.3 Propensity Score Matching.

To carry out this evaluation, sample enterprises are divided into two groups based on the intensity of their R&D investment: the top 50%with higher R&D investment and the bottom 50%with lower R&D investment. Bias was reduced by comparing the average effects of the treatment and control groups.

After a series of propensity score matching, the results in Table 6 indicate that R&D subsidies significantly improve the performance of enterprises and promote sustainable operations at a 1%significance level. Specifically, the statistical test shows that the performance of enterprises receiving R&D subsidies is significantly better than that of those not receiving such subsidies, The definitions of the variables are outlined in Table 6.

Table 6. PSM robustness test considering endogeneity

Enterprise performance		1 to 1 with back matching	Calipers match	Kernel matching
The first 50%is 0 and the last 50%is 1.	R & D investment	2.67e-12** (1.41e-12)	2.67e-12*** (1.41e-12)	2.01e-11 ** (2.02e-12)

5.3 Mediating Effect Test

It is clear that financing constraints and product market competitiveness exhibit a complete mediating effect. This indicates that enterprise R&D investment does not directly enhance performance ;instead, it operates through two pathways: alleviating financing constraints and improving product market competitiveness.

Specifically, when enterprises increase their R&D investment, they can attract more funds through innovation, thereby reducing constraints caused by insufficient funds. Concurrently, new technologies or improved products resulting from R&D activities

enhance the market competitiveness of enterprises, which in turn promotes overall enterprise performance, The definitions of the variables are outlined in Table 7.

Table 7. Test results of mediation effect

Mediating variable	Effect	Financing constraints	Product market competitiveness
R & D investment	Mediating effect	1.80e-14 *** (2.95e-14)	7.51e-13** (3.69e-13)
	Direct effect	8.35e-13*** (5.26e-13)	1.13e-13 ** (6.06e-13)

5.4 Analysis of Moderating Effect

To analyze these moderating effects in depth, interaction terms between explanatory variables and moderating variables are included in the study. The explanatory variables are the main independent variables, while the moderators test their effects on the relationship between the explanatory variables and firm performance. To reduce collinearity, all variables are mean-centered, which involves subtracting the average value of each variable from its original value to improve the model's estimation accuracy.

The test results of the moderating effect are presented in. The findings indicate that ownership concentration negatively moderates the relationship between enterprise R&D investment and performance, The definitions of the variables are outlined in Table 8.

Table 8. Adjustment Effect Test Results

Variables	Enterprise performance	
R & D investment	5.81e-12*** (2.06e-12)	1.11e-10*** (3.81e-11)
Ownership concentration	0.0017*** (0.00011)	
Analyst attention		0.0433*** (0.00217)
R & D investment * equity concentration	-1.52e-13*** (5.40e-14)	
R & D investment * analyst attention		3.40e-12*** (9.99e-13)
Time/individual fixation	YES	YES
Control variable	YES	YES
N	4383	4340

5.5 Heterogeneity Analysis

5.5.1 Heterogeneity of Firm Size.

The test results for enterprise size heterogeneity, shown in Table 9, indicate that R&D investment has a more pronounced effect on enhancing business performance in

large-scale enterprises. These enterprises typically have greater liquidity to allocate towards R&D and innovation.

Table 9. Heterogeneity Test of Enterprise Size

Variables	Enterprise performance	
	Firm size is above the median	Business size is below the median
R & D investment	3.48e-12***	6.48e-11**
	(1.31e-12)	(2.98e-11)
Time/individual fixation	YES	YES
Control variable	YES	YES
Constant	-1.976	-28.541
	(2.838)	(50.674)
N	3567	3013

5.5.2 Enterprise Type.

The heterogeneity test results for enterprise types in Table 10 indicate that R&D investment in state-owned enterprises (SOEs) significantly enhances their operating performance. SOEs benefit from more preferential policies, which support and amplify the positive effects of R&D investment on performance improvement. This shows that R&D investment in SOEs not only directly fosters their own development but also contributes to technological progress, industrial upgrading, and overall national economic growth on a broader scale.

This finding holds important theoretical and practical significance for understanding the role of SOEs in economic development. It highlights how policy design can optimize the effects of R&D investment, making it a critical consideration for improving the efficacy of such investments.

Table 10. Heterogeneity Test Results of Enterprise Type

Variables	Enterprise performance	
	State-owned enterprises	Non-state-owned enterprises
R & D investment	6.48e-11**	1.69e-12
	(2.98e-11)	(1.63e-12)
Time/individual fixation	YES	YES
Control variable	YES	YES
Constant	28.541	-1.707
	(50.674)	(2.779)
N	3013	3048

5.5.3 Industry of the Enterprise.

The heterogeneity test results for industry characteristics in Table 11 indicate that R&D investment in labor-intensive and asset-intensive enterprises significantly enhances their business performance. This suggests that heavy asset enterprises prioritize innovative equipment to improve total factor productivity. These findings demonstrate that investment in innovation activities can be effectively translated into performance growth, promoting overall development and profitability.

Further analysis reveals that enterprises with substantial fixed assets, which rely heavily on these assets for production and operations, tend to focus their R&D investment on procuring and utilizing innovative equipment. This trend reflects a core strategy of these enterprises: to enhance automation and intelligence in production processes through the adoption of the latest technologies and efficient equipment, thereby improving total factor productivity, The definitions of the variables are outlined in Table 11.

Table 11. Heterogeneity of Industry Characteristics

Variables	(1) Labor-intensive	(2) Asset intensive	(3) Technology intensive
R & D investment	2.56e-11 ***	9.71e-12 ***	4.57e-11
	(7.71e-12)	(3.58e-12)	(2.85e-11)
Control variable	Yes	Yes	Yes
Enterprise fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Constant	-0.4499***	0.1713	-26.625
	(0 .1440)	(0.16868)	(58.618)
N	2291	1319	3124

5.5.4 Region of the Enterprise.

This suggests that the favorable economic conditions and well-developed infrastructure in these regions amplify the impact of R&D investment on enterprise performance.

These external conditions provide an optimal environment for R&D activities, allowing R&D investments to be more effectively transformed into business results, thereby significantly enhancing the business performance of enterprises in these regions, The definitions of the variables are outlined in Table 12.

Table 12. Heterogeneity based on the region where the enterprise is located

Variables	(1) East	(2) West	(3) Middle
R & D investment	6.41e-11 ***	1.07e-10	2.54e-10**
	(2.22e-11)	(8.73e-11)	(1.22e-10)
Control variable	Yes	Yes	Yes
Enterprise fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Constant	-30.240	13.766***	15.353***
	(47.126)	(3.1717)	(3.717)
N	4420	1322	1072

6 Conclusions and Recommendations

6.1 Research Conclusion

This paper finds that R&D investment enhances enterprise performance, with empirical results remaining robust after a series of tests. Based on these findings, an action path is constructed to explain the relationship between R&D investment and enterprise performance. The mediation effect test concludes that R&D investment boosts performance by alleviating financing constraints and increasing product market competitiveness, regulated jointly by internal control and external governance. The results indicate that:

(1)State-Owned Enterprises (SOEs): R&D investment significantly boosts business performance, supported by preferential policies that favor SOEs.

(2)Labor-Intensive and Asset-Intensive Enterprises: These enterprises see a more pronounced improvement in business performance from R&D investment, indicating a focus on innovative equipment to enhance total factor productivity.

(3)Regional Differences: In the eastern and central regions, R&D investment more significantly improves business performance, suggesting that favorable economic conditions and well-developed infrastructure in these areas enhance the effectiveness of R&D activities.

6.2 Research Recommendations

To alleviate the pressure of relying on a single financing channel, enterprises are encouraged to explore diversified financing options, including bank loans, equity financing, bond issuance, and private equity. The following measures can further support this effort:

Government Support: The government can provide financing guarantees, subsidized interest rates, venture capital, and other support measures to help enterprises reduce financing costs and increase financing opportunities.

Financial Innovation: Financial institutions are encouraged to develop innovative financing products that cater to the needs of enterprises, such as exclusive financing schemes for technology-based enterprises and supply chain finance.

Credit Rating System: Establishing a robust enterprise credit rating system and improving the creditworthiness of enterprises can help them secure better financing conditions.

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