THE IMPACT OF EQUITY STRUCTURE ON CORPORATE R&D INVESTMENT

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ABSTRACT
R&D investment has emerged as the core determinant of enterprises' competitiveness. Using the data of A-share listed companies from 2010 to 2020, this paper constructs a two-way fixed effect model to explore the impact of equity structure on corporate R&D investment. The research findings are as follows. Equity concentration exhibits an inverted U-shaped nonlinear relationship with R&D investment. Moderate equity concentration promotes R&D investment, while excessive concentration hinders it. Equity balances significantly contribute to R&D investment. Agency costs mediate the influence of equity concentration and equity balances on R&D investment, and ESG plays a moderating role. Moreover, the impact of equity structure on R&D investment varies across different ownership types. This study offers empirical support for enterprises to formulate sound equity structure and R&D investment strategies.
Keywords: Equity Concentration, Equity Balances, R&D Investment, Agency Costs, ESG

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INTRODUCTION

R&D investment has emerged as a critical determinant of corporate competitiveness and sustainable development in contemporary markets. As primary actors in technological advancement, enterprises' innovation capabilities significantly influence not only their own performance but also national innovation capacity and economic competitiveness. Empirical evidence from the China Enterprise Confederation (2024) reveals substantial growth in corporate R&D investments, with China's top 500 enterprises collectively investing 1.81 trillion yuan in 2023 - a 14.89% year-on-year increase, while simultaneously expanding their patent portfolios by 7.66%.

The equity concentration reflects the degree of control of major shareholders in the company, while the equity balance reflects the power comparison between multiple major shareholders Chen et al. (2024). The Chinese government has implemented robust policy frameworks to foster firm innovation, particularly through equity structure optimization. Notable initiatives include proposals during the 2024 National People's Congress sessions advocating for enhanced equity investment in early-stage technological ventures, emphasizing the strategic role of state capital in guiding private investment toward science and technology sectors. These policy developments underscore the growing significance of equity structure in facilitating corporate innovation.

The possible contributions of this paper are as follows. Firstly, most of the existing studies focus on the impact of a certain aspect of the equity structure on a firm's R&D investment. This paper incorporates both the equity concentration and the equity balance into the same analytical framework, and simultaneously examines the roles played by these two factors, providing new insights for a deeper understanding of the relationship between complex ownership structure models and a firm's R&D investment.

Secondly, existing research predominantly emphasizes direct effects, while there is a lack of exploration into the mechanism by which the equity structure influences R&D investment. This paper will use a mediating effect model to conduct an empirical analysis of the mediating role of agency costs between the equity balance degree and a firm's R&D investment, revealing how the equity structure promotes corporate innovation by reducing agency costs.

Thirdly, this paper empirically tests the positive moderating effect of ESG performance on the relationships among equity concentration, equity balance, and a firm's R&D investment. This not only expands the theoretical boundaries of ESG research but also provides empirical evidence for firms to enhance their R&D investment capabilities by improving their ESG performance.

This study consequently examines the relationship between equity structure (equity concentration and equity balance) and corporate R&D investment within Chinese enterprises. The research particularly focuses on identifying optimal equity concentration thresholds that maximize innovation outcomes, contributing to both academic literature and practical corporate governance applications.

LITERATURE REVIEWS

Equity concentration is an important indicator for measuring the distribution of corporate control rights, and different levels of equity concentration may have varying impacts on a firm's innovation decision-making. Similarly, Qin (2018) studied the influence of the equity structure on a firm's R&D investment and found that there is a significant negative correlation between state-owned property rights and a firm's R&D investment. In contrast, the effect of equity concentration on a firm's R&D investment is significantly positive, and changes in the equity structure are not conducive to the increase in a firm's R&D investment. Shi (2023) investigated the relationship among equity concentration, the CEO's technical background, and corporate

innovation, and discovered that when a firm's CEO has a technical background, the promoting effect of high equity concentration on innovation is more pronounced.

Under a centralized equity structure, non-executive directors may play a crucial role in innovation governance. Zhou et al. (2023) studied the impact of an asymmetric equity structure on a firm's R&D investment and compared two types of imbalanced equity structures: the dual-class equity structure and the stock pyramid structure. They found that compared with pyramidal firms, dual-class firms engage in more R&D investments.

The nature of shareholders has a significant influence on the choice of a firm's innovation strategy. Usman et al. (2017) in their research on China's high-tech industry, found that equity structures such as institutional shareholding and managerial shareholding have a negative impact on a company's R&D investment. Additionally, state-owned equity has a positive moderating effect between institutional equity and a firm's R&D investment, but there is no moderating effect between managerial equity and a firm's R&D expenditure decision. Tripathi (2025) studied the relationship between the equity structure and technical efficiency in India's utility industry. The research results indicate that the equity structure plays an important role in technical efficiency, with state-owned enterprises having an average technical efficiency of 72%, while private enterprises have an average technical efficiency of 63%.

The equity structure from a single dimension cannot comprehensively reflect the impact of the equity structure on corporate innovation, which limits the applicable scope of the research conclusions. In response to this, Chen et al. (2024) integrated the equity structure and the degree of equity balance into the same research framework, and simultaneously paid attention to the impacts of both on a firm's innovation performance. The study found that there is an inverted U-shaped relationship between equity concentration and innovation performance, meaning that both excessively low and excessively high concentrations are not conducive to innovation; equity balance has a positive impact on innovation performance; R&D investment plays a mediating role between the equity structure and innovation performance, and market competition moderates the relationship between equity concentration and innovation performance. However, the moderating effect of equity balance on innovation performance is not significant.

In summary, most of the relevant studies on the impact of the equity structure on a firm's R&D investment in the Chinese context use the CSMAR database and take Chinese A-share listed companies as the research objects. They conduct causal effect tests by constructing econometric models such as two-way fixed effects Zhang and Yu (2023); Chen et al. (2024) and the system GMM model Qin (2018). These studies provide data and model references for this paper. However, as pointed out in the introduction of this paper, existing studies still have some deficiencies, such as insufficient integrated research on the equity structure, and the unclear mechanisms and moderating effects of how the equity structure affects R&D investment.

Hypotheses

Moderate equity concentration is conducive to enhancing large shareholders' monitoring capabilities and enabling firms to prioritize long - term strategies, such as R&D investment. According to the principal-agent theory, firms with dispersed shareholdings often encounter severe agency problems between shareholders and management Al-Faryan (2024); Dong et al. (2021). In these cases, the diffusion of shareholder power leads to insufficient external supervision of management. As a result, managers may prioritize short-term profitability over long-term R&D investment. Conversely, large shareholders typically possess greater risk tolerance and can drive firms to engage in high-risk, high-return frontier technology R&D, rather than relying solely on short- term market returns Wang et al. (2023). Thus, moderate equity concentration can strengthen large shareholders' control and enhance the stability of firms' innovation investment.

However, when equity concentration is excessive, it may impede firms' R&D investment. A highly concentrated equity structure can prompt majority shareholders to exhibit short-sighted behavior, especially in volatile market conditions or under stringent financing constraints Boubaker et al. (2021). In such scenarios, they may be more inclined to pursue short-term benefits rather than long-term innovation. Moreover, high equity concentration may trigger agency problems between controlling and small-medium shareholders Al-Faryan (2024). Controlling shareholders might abuse their dominant position through “tunneling behavior”, such as misappropriating firm resources via insider trading or profit-shifting, instead of investing in innovation. Additionally, excessive equity concentration can undermine the firm's internal monitoring, limiting innovation decisions to the subjective judgments of a few individuals and reducing the flexibility of innovation investment Ruiyang et al. (2021). Consequently, the relationship between equity concentration and firms' R&D investment is likely an inverted U-shaped curve. That is, moderate equity concentration is most favorable for innovation, while excessive concentration suppresses it. Based on this, Hypothesis 1 is proposed.

H1: Equity concentration has an inverted U-shaped nonlinear effect on firms' R&D investment.

The degree of equity balances reflects the power equilibrium among different shareholders within an enterprise. When the equity structure is more balanced, with multiple large shareholders holding a certain proportion of equity, it can effectively prevent a single large shareholder from abusing control and improve the enterprise's governance level Xu et al. (2019). In this situation, mutual supervision among major shareholders reduces their opportunistic behavior, guiding enterprises to focus on long-term development rather than short-term arbitrage. Furthermore, a higher degree of equity balances often leads to a more independent board of directors, with enhanced influence of non-executive directors. This allows for greater supervision and guidance in innovation decision-making Yaru (2024). Such a governance mechanism mitigates information asymmetry in innovation investment, improves resource allocation efficiency, and encourages firms to adopt more forward-looking technological strategies. Additionally, it optimizes the enterprise's capital allocation structure, making it more likely to support long-term innovation projects in financing decisions. In firms with higher equity balances, the interaction between controlling and other shareholders regarding innovation investment can drive the discovery of better innovation strategies and more robust decision-making Cheng (2024). Thus, Hypothesis 2 is formulated.

H2: The degree of equity balances significantly promotes firms' R&D investment.

Agency costs play a crucial role in the relationship between equity structure and R&D investment. When equity is highly dispersed, the first-type agency problem (conflict between shareholders and management) is severe Dong et al. (2021). Single-shareholder monitoring incentives are weak, and managers may pursue short-term, low-risk strategies for personal gain instead of investing in high-risk, long-term innovation. As equity concentration rises, large shareholders' monitoring capabilities increase, alleviating this problem Xu et al. (2022). Large shareholders, motivated by the firm's long - term growth, can reduce management's opportunistic behavior through strengthened governance mechanisms, enhancing the firm's innovation orientation Wan et al. (2023). Nevertheless, excessive equity concentration gives rise to the second-type agency problem, intensifying the conflict between controlling and small-medium shareholders Al-Faryan (2024). Controlling shareholders may engage in "tunneling behavior" to misappropriate corporate resources, reducing long-term innovation investment Wang et al. (2022) Wang and Xu (2023). Therefore, Hypothesis 3 is put forward.

H3: Agency costs play a mediating role. Equity concentration affects firms' R&D investment through an inverted U - shaped impact on agency costs.

In enterprises with a balanced shareholding structure, the mutual constraints among multiple major shareholders can prevent power from concentrating in the hands of a single shareholder,

reducing the likelihood of agency problems between controlling and small-medium shareholders Xu et al. (2019). This forces controlling shareholders to make more transparent and rational decisions, improving the stability of innovation investment and long-term technology planning Yaru (2024). Moreover, a higher degree of equity balances optimizes the corporate governance structure, enhances board independence, and boosts external investors' confidence Qinran (2019). In such firms, boards are more independent and professional, and non-executive directors and institutional investors have greater influence in innovation investment decision-making, reducing information asymmetry and agency costs. Hence, Hypothesis 4 is proposed:

H4: Agency costs play a mediating role. The degree of equity balances promotes firms' R&D investment by reducing agency costs.

ESG also influences the relationship between equity structure and R&D investment. Firms with high ESG levels face stricter social responsibility requirements and enjoy more policy support and market recognition Long et al. (2023). In these firms, large shareholders' long-term investment incentives are strengthened, and their monitoring role is more pronounced. Short-term behavior by major shareholders incurs high market penalties, while long - term innovation investment generates higher social capital and brand value Li and Li (2024). Thus, ESG enhances the positive impact of moderate equity concentration on corporate innovation. However, when equity concentration is excessive, ESG may exacerbate controlling shareholders' short-sighted behavior. Meeting ESG requirements demands substantial long-term investment, which can burden conservative large shareholders and prompt them to cut innovation investment for short-term financial stability Li et al. (2023). Therefore, Hypothesis 5 is postulated.

H5: ESG has a moderating effect. It amplifies the impact of equity concentration on firms' R&D investment.

In the context of ESG, the governance effect of equity balances becomes more prominent. ESG requires firms to maintain high levels of transparency in environmental, social, and governance aspects. Firms with high equity balances typically have better disclosure mechanisms and stricter external regulations, strengthening shareholder mutual monitoring, reducing resource misappropriation by controlling shareholders, and facilitating more capital and resources for innovation Li and Li (2024). Additionally, ESG-driven long-term investment requirements in environmental and social responsibility align with the stability and sustainability orientation of firms with high equity balances, enhancing their innovative capabilities Long et al. (2023). Thus, Hypothesis 6 is presented.

H6: ESG has a moderating effect. It amplifies the impact of equity balances on firms' R&D investment.

From the literature review, the research framework of this paper is shown in Figure 1.

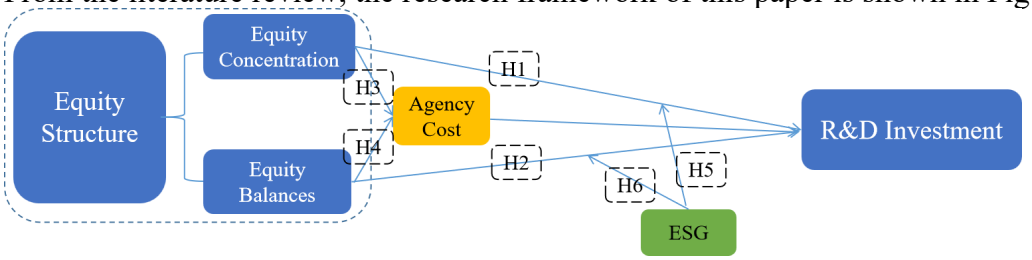

Figure 1 Conceptual Framework

RESEARCH METHODOLOGY

This study utilizes Chinese A-share main board listed companies as its research sample. The data employed are sourced from the CSMAR. To mitigate the potential confounding effects of the COVID-19 pandemic on the regression results, the research window is set from 2010 to

2020. Ultimately, unbalanced panel data of 3,307 A-share main board listed companies, comprising 19,376 valid observations, are obtained. Data cleaning and empirical analyses are conducted using Stata 17.0 software.
The definition of all the variables in this paper is shown in Table 1

Table 1 Variable definitions

Abbreviation	Variable name	Variable Definition
RD	R&D investment	Natural logarithm of R&D investment
Ratio1	Equity concentration	Percentage of shares number held by the largest shareholder
Ratio2	Equity balances	Number of shares held by the second to fifth largest shareholder / Number of shares held by the first largest shareholder
Cost	Agency cost	Administrative expenses/main operating income
ESG	ESG performance	CSI ESG Rating
Size	Enterprise size	Natural logarithm of asset size
Lev	Level of financial leverage	Total liabilities/total assets of the enterprise
ROE	Corporate profitability	Net profit/closing assets
Growth	Corporate Growth	(Current operating income - prior period's operating income)/prior period's operating income
TobinQ	Enterprise value	Tobin's Q
Firmage	Years of business establishment	Natural logarithm of the number of years the business has been established
Indstry	Virtual variable	industry fixed effect
Year	Virtual variable	time fixed effect

Models

This paper constructs a two-way fixed effect model, and the model is set up as equation (1) and (2). In the above model, in the below equation, i denotes listed companies and t denotes the year. RD_{it} is the R&D investment of listed company i in year t. $Ratio1_{it}$ is the first core explanatory variable of this paper i.e. equity concentration, the introduction of $Ratio1^2{}_{it}$ can test whether there is a nonlinear inverted U-shaped relationship between equity concentration and R&D investment. $Ratio2_{it}$ is the second core explanatory variable of this study, i.e. the degree of equity balances. The coefficient object focused on in this paper is α_1、α_2、β_1. $Control_{it}$ is the set of control variables selected in this study. μ_i is the industry fixed effect, λ_t is the year fixed effect, and ε_{it} denotes the random perturbation term.

$$\mathrm{RD_{it}} = \alpha_0 + \alpha_1 \mathrm{Ratio1_{it}} + \alpha_2 \mathrm{Ratio1^2{}_{it}} + \alpha_n \sum \mathrm{Control_{it}} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

$$RD_{it} = \beta_0 + \beta_1 Ratio2_{it} + \beta_n \sum Control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

In this paper, we refer to the method of Ting (2022) and use a two-step method to test the mechanism. The specific model settings are shown in equations (3) and (4). Model (3) is used to test the impact of equity concentration on agency costs, if α_1 and α_2 are significant, it means that changes in equity concentration will cause corresponding changes in agency costs; model (2) tests the impact of equity balance on agency costs, and the significance of β_1 reflects the relationship between equity balance and agency costs. The significance of α_1 reflects the relationship between the degree of equity balance and agency cost. Here, we focus on the significance of the coefficients α_2 and β_1.

$$Cost_{it} = \alpha_0 + \alpha_1 Ratio1_{it} + \alpha_2 Ratio1^2{}_{it} + \alpha_n \sum Control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

$$Cost_{it} = \beta_0 + \beta_1 Ratio2_{it} + \beta_n \sum Control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

In order to investigate the moderating effect of ESG performance on the relationship between equity structure and R&D investment, this study constructs a moderating effect model by introducing interaction terms. The coefficients of $Ratio1\_ESG_{it}$, $Ratio1^2\_ESG_{it}$ and $Ratio2\_ESG_{it}$ are the interaction terms of equity concentration, equity concentration squared term and equity balance with ESG performance, respectively. By analyzing the coefficients of α_3, α_4 and β_2, we can determine whether the moderating effect of ESG performance is significant.

$$RD_{it} = \alpha_0 + \alpha_1 Ratio1_{it} + \alpha_2 Ratio1^2{}_{it} + \alpha_3 Ratio1\_ESG_{it} + \alpha_4 Ratio1^2\_ESG_{it} + \alpha_5 ESG_{it} + \alpha_n \sum Control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

$$RD_{it} = \beta_0 + \beta_1 Ratio2_{it} + \beta_2 Ratio2\_ESG_{it} + \beta_3 ESG_{it} + \beta_n \sum Control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

EMPIRICAL RESEARCH RESULTS

Benchmark regression results

The benchmark regression results are presented in Table 2. Taking the regression results with the inclusion of control variables as the benchmark, the coefficient of Ratio1 is 0.8991, and the coefficient of Ratio1² is -2.3223. Both coefficients pass the 1% significance test, indicating a significant inverted U-shaped relationship between equity concentration (Ratio1) and R&D investment. Specifically, moderate equity concentration promotes R&D investment, while excessive concentration inhibits innovation. This finding corroborates Research Hypothesis H1.

The coefficient of Ratio2 is significantly 0.5527, suggesting that the degree of equity balance has a notable positive impact on R&D investment. A higher level of equity balances can effectively prevent a single major shareholder from abusing control, optimize the corporate governance structure, enhance resource allocation efficiency, and encourage enterprises to adopt more forward-looking technology strategies, thereby increasing R&D investment. This result validates Research Hypothesis H2.

Table 2 Benchmark regression results

	(1) **RD**	**(2)** **RD**	**(3)** **RD**	**(4)** **RD**
Ratio1	0.8991***		0.1576***	
	(15.0007)		(3.3246)	
$Ratio1^2$	-2.3223***		-0.8745***	
	(-7.8407)		(-3.4279)	
Ratio2		0.5527***		0.0917***
		(13.7049)		(2.7796)
_cons	17.5282***	17.5051***	2.1364***	2.1442***
	(885.1334)	(816.5568)	(11.4275)	(11.4814)
Controls	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes
Ind fixed	Yes	Yes	Yes	Yes
N	19376	19376	19376	19376
R^2	0.132	0.131	0.503	0.503

Note: *** p<0.01, ** p<0.05, * p<0.1, standard error in parentheses.

Robustness Tests

This paper conducts robustness tests by substituting variables and adding city fixed effects (Table 3). Columns (1) and (2) use R&D investment as a share of operating income as a replacement variable (RD_SUB). Columns (3) and (4) use the proportion of shares held by the top five shareholders as a replacement explanatory variable for equity concentration, and the proportion of shares held by the top five shareholders number of shares held by the top ten shareholders as a replacement variable for equity balances. City fixed effects are added in columns (5) and (6).

Table 3 Robustness test

	(1) **RD_SUB**	**(2)** **RD_SUB**	**(3)** **RD**	**(4)** **RD**	**(5)** **RD**	**(6)** **RD**
Ratio1	1.4270***				0.1481***	
	(7.5672)				(3.0915)	
$Ratio1^2$	-4.8315***				-1.0743***	
	(-4.4433)				(-4.0695)	
Ratio2		0.2725**				0.1281***
		(2.2748)				(3.8653)
Ratio1_SUB			2.4285***			
			(8.4864)			
Ratio12_SUB			-2.2898***			
			(-8.6047)			
Ratio2_SUB				0.2480***		
				(3.7029)		
_cons	7.8668***	7.9924***	1.4869***	2.0854***	1.7048***	1.7103***
	(12.8271)	(13.0509)	(7.2579)	(11.1161)	(9.1110)	(9.1507)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Ind fixed	Yes	Yes	Yes	Yes	Yes	Yes
Urban fixed	No	No	No	No	Yes	Yes
N	19376	19376	19376	19376	19360	19360
R^2	0.249	0.247	0.505	0.503	0.585	0.585

Note: *** p<0.01, ** p<0.05, * p<0.1, standard error in parentheses.

Endogeneity Test

To address possible endogeneity issues, this paper uses the instrumental variable approach for testing (Table 4). In this paper, equity concentration in the lagged period (IV-lagRatio1) and equity checks and balances in the lagged period (IV-lagRatio2) are used as instrumental variables. The coefficients of IV-lagRatio1 and IV-lagRatio2 are significantly positive and the F-value of the weak instrumental variable test is much larger than 10.The Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic also indicate that the selection of instrumental variables is consistent with the exclusion constraint. After mitigating the endogeneity problem, the Ratio1 coefficient is 0.1017, the Ratio12 coefficient is -0.9341, and the Ratio2 coefficient is 0.0826, and the inverted U-shape effect of equity concentration and the positive effect of equity checks and balances remain significant.

Table 4 Instrumental variables approach

	(1) Ratio1	(2) RD	(3) Ratio2	(4) RD
IV-lagRatio1	0.9528 ***			
	(361.38)			
Ratio1		0.1017*		
		(1.91)		
Ratio1²		-0.9341***		
		(-3.31)		
IV-lagRatio2			0.9254 ***	
			(270.45)	
Ratio2				0.0826**
				(2.32)
_cons	0.9312	0.4561	0.8671	0.4559
Controls	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes
Industry Fixed	Yes	Yes	Yes	Yes
N	15349	15349	15349	15349
F	5675.78***		4543.26***	
Kleibergen-Paap rk LM	1352.935***		2487.347***	
Cragg-Donald Wald F	4412.258***		5385.344***	

Note: *** p<0.01, ** p<0.05, * p<0.1, standard error in parentheses.

Mediating effects of agency costs

Table 5 examines the mediating role of agency costs. The coefficient of Ratio1 is -0.0332, and the coefficient of Ratio1² is 0.0637. These values indicate an inverted U - shaped relationship between equity concentration and agency costs, thereby supporting Hypothesis H3. Specifically, moderate equity concentration serves to reduce agency costs and promote innovation, while excessive concentration exacerbates the agency problem, consequently exerting an inverted U-shaped influence on R&D investment. The coefficient of Ratio2 is -0.0171, suggesting that equity balances significantly reduce agency costs. This finding confirms Research Hypothesis H4. By optimizing the governance structure, equity balances mitigate agency costs, thereby facilitating an increase in R&D investment.

Table 5 Mechanism test: agency costs

	(1) Agency cost	(2) Agency cost
Ratio1	-0.0332 ***	
	(-10.00)	
Ratio1²	0.0637 ***	
	(3.47)	
Ratio2		-0.0171***
		(-7.73)
_cons	0.2588 ***	0.2554 ***
	(25.33)	(24.95)
Controls	Yes	Yes
Year fixed	Yes	Yes
Ind fixed	Yes	Yes
N	19376	19376
R2	0.3382	0.3369

Note: *** p<0.01, ** p<0.05, * p<0.1, standard error in parentheses.

Moderating effects of ESG

Table 6 tests the ESG moderating effect. The Ratio1_ESG coefficient is -0.1409 and the Ratio1²_ESG coefficient is -0.8565, which suggests that ESG reinforces the inverted U-shape effect of equity concentration, and Hypothesis H5 holds. In firms with higher levels of ESG, a moderately concentrated equity structure promotes innovation more strongly, but the negative impact of over-concentration is also more significant. The Ratio2×ESG coefficient is significant at 0.0827, which suggests that ESG environments further amplify the positive impact of equity balances on R&D investment, which validates hypothesis H6.

Table 6 Moderated effects test: ESG performance

	(1) **RD**	**(2)** **RD**
Ratio1	0.1465 ***	
	(3.09)	
Ratio1²	-0.6840 ***	
	(-2.63)	
Ratio1×ESG	-0.1409***	
	(-2.82)	
Ratio1²×ESG	-0.8565 ***	
	(-3.10)	
Ratio2		0.0906 ***
		(2.75)
Ratio2×ESG		0.0827**
		(2.40)
ESG	0.0494 ***	0.0511***
	(7.09)	(7.34)
_cons	2.0720 ***	2.0989 ***
	(11.06)	(11.19)
Controls	Yes	Yes
Year fixed	Yes	Yes
Ind fixed	Yes	Yes
N	19376	19376
R2	0.5055	0.5050

Note: *** p<0.01, ** p<0.05, * p<0.1, standard error in parentheses.

Heterogeneity

Table 7 presents the heterogeneity effects of equity structure on R&D investment across different ownership types. Evidently, the promoting effects of equity concentration and balances on R&D investment are more prominent in state-owned enterprises. This might be attributed to the larger scale and more intricate governance structures of state-owned enterprises. Such characteristics necessitate more effective balances mechanisms to ensure adequate R&D investment.

Table 7 Ownership heterogeneity

	(1) State enterprise RD	(2) Non-state enterprise RD	(3) State enterprise RD	(4) Non-state enterprise RD
Ratio1	0.6046***	0.1548***		
	(5.5683)	(3.0445)		
$Ratio1^2$	-3.9520***	0.3105		
	(-7.3056)	(1.1534)		
Ratio2			0.3271***	0.0442
			(4.4335)	(1.2629)
Controls	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes
Ind fixed	Yes	Yes	Yes	Yes
N	6300	13076	6300	13076
R^2	0.489	0.530	0.487	0.530

Note: *** p<0.01, ** p<0.05, * p<0.1, standard error in parentheses.

DISCUSSION

This study still has some limitations. This research solely selects Chinese A-share listed companies as samples, and this limited scope has somewhat affected the generalizability of the research findings. China's capital market features a unique institutional environment, economic development stage, and cultural background. A-share listed companies also have their own characteristics in terms of ownership structure and corporate governance. These factors make it difficult to directly apply the conclusions drawn from A-share listed companies to enterprises in other countries or regions. In view of this, future research can expand the sample scope and examine the correlation between ownership structure and R&D investment in other countries or regions. During the research process, it is possible to compare the characteristics of capital markets in different countries, such as the regulation of ownership structure by laws and regulations and the degree of investor protection, and analyze how these differences affect the relationship between ownership structure and R&D investment. It is also feasible to study the innovation concepts and strategies of enterprises under different cultural backgrounds and their moderating effects on the relationship between ownership structure and R&D investment. Such research will assist enterprises and policymakers in better understanding and applying ownership structure to promote R&D investment on a global scale, thereby driving the innovative development of enterprises.

The influencing mechanism of ownership structure on enterprises' R&D investment is diverse and complex. This article focuses on the key mediating channel of agency costs, but there may be other paths of influence. First, from the perspective of financing capabilities, the ownership structure affects the difficulty and cost of enterprise financing, thereby influencing R&D investment Zhao et al. (2023). In enterprises with concentrated ownership, major shareholders can more easily gain the trust of external investors by virtue of their strong resource integration capabilities and reputation, helping the enterprise obtain debt financing or attract strategic investors. In contrast, enterprises with dispersed ownership have a complex decision - making process and may have difficulty reaching an agreement on financing decisions, increasing financing difficulty and cost and suppressing R&D investment. Second, the shaping of corporate culture and innovation atmosphere is closely related to the ownership structure Han and Jiang (2025). In enterprises with a high degree of ownership balance, shareholders monitor each other, prompting the enterprise to establish a transparent and fair corporate culture and encouraging employees to actively participate in innovation activities. It would create a favorable internal environment for R&D investment. In such an atmosphere, employees are bold enough to put forward innovative ideas, and enterprises are more willing to invest

resources in innovation projects. Conversely, in enterprises with highly concentrated ownership and a lack of checks and balances, decision - making may overly rely on major shareholders, and the corporate culture may be relatively conservative, which is not conducive to stimulating innovation vitality and has a negative impact on R&D investment.

CONCLUSION

The findings reveal four key insights. First, equity concentration has an inverted U - shaped influence on R&D investment. Moderate concentration promotes R&D investment, while excessive concentration inhibits it. Equity balances significantly boost R&D investment. Second, agency costs act as a mediator. Equity concentration affects R&D investment through an inverted U - shaped impact on agency costs, and equity balances promote R&D investment by reducing agency costs. Third, ESG plays a moderating role. It amplifies the impact of equity concentration and strengthens its inverted U - shaped relationship with R&D investment, and also enhances the positive effect of equity balances on R&D investment. Finally, there is heterogeneity in the impact of equity structure on R&D investment across different property - rights enterprises.

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