

Exploring the Impact of Major Shareholder Equity Pledging on Enterprise Innovation: A Moderated Mediation Model

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Abstract: This study investigates how agency issues stemming from major shareholders' equity pledges affect enterprise innovation through managerial characteristics. This paper constructs a theoretical framework to examine the effect of controlling shareholder equity pledging on enterprise innovation, focusing on two key managerial attributes: risk preference and managerial ability. It develops a moderated mediation model in which managerial risk preference mediates the relationship between equity pledging and enterprise innovation, while managerial ability moderates this mediating effect. Six hypotheses are proposed and tested using standardized empirical methods. Empirical results demonstrate that equity pledging by major shareholders is negatively related to managers' risk preferences, which in turn fully mediate the impact of equity pledging on enterprise innovation. Furthermore, managerial ability negatively moderates the mediating effect of managerial risk preference. This study enriches the literature by incorporating the internal heterogeneity of managers into the analysis of equity pledge outcomes. By highlighting the interplay between managerial risk preferences and abilities, it contributes to the understanding of how personal attributes of executives shape the consequences of major shareholders' financial behavior on firm-level innovation. The findings aim to inform enterprises on how to structure equity pledge financing more judiciously, enhance managerial effectiveness, mitigate operational risks, and foster innovation.

Keywords: Managerial Risk Preference; Managerial Ability; Moderated Mediation; Equity Pledge; Enterprise Innovation

1. Introduction

Over the past three decades, China's capital

market has evolved into the world's largest emerging capital market. Despite this rapid development, enterprises in China continue to face serious challenges related to limited financing channels and high financing costs, commonly referred to as the problems of "difficult financing" and "expensive financing"^[1]. In response to these constraints, equity pledges, particularly by controlling shareholders, have become a prevalent means of securing capital. Consequently, the economic implications of equity pledging have attracted increasing scholarly attention and emerged as a key topic in corporate finance research^[2]. In an increasingly competitive market landscape, innovation is the core driving force for enterprise growth and sustainability. However, innovative activities are inherently risky, capital-intensive, and demand sustained investment to ensure continuity in research and development (R&D). The equity pledging of controlling shareholders is widely interpreted as a signal of severe financing constraints^[2]. Although equity pledging serves as a financial instrument, the role of controlling shareholders extends beyond capital provision. As key actors in corporate governance, they significantly influence strategic decisions, including those related to innovation^[3]. Against this backdrop and building on existing literature, this study explores the impact of controlling shareholders' equity pledging on enterprise innovation, and also considers litigation risk and ESG (Environmental, Social, and Governance) performance as contextual factors^[4].

This study mainly investigates the inherent heterogeneity of managers, specifically managerial risk preference and managerial ability, as key factors influencing enterprise innovation. At the micro level, existing literature on the economic consequences of equity pledging has predominantly focused on issues such as control transfer risks in listed companies, enterprise value, and investment efficiency.

Evidence has shown that managerial risk preference directly affects an enterprise's willingness to take risks, while managerial ability influences the firm's operational efficiency. Yet, in the context of major shareholders' equity pledges, the specific impact of these two managerial dimensions on enterprise innovation remains insufficiently explored and theoretically inconclusive^[5]. To address this gap, the present study integrates managerial characteristics into the analytical framework linking major shareholder equity pledging and enterprise innovation. It conducts an in-depth examination of how managerial attributes affect enterprise innovation in the context of major shareholder equity pledging, thereby contributing to the advancement of existing theoretical models.

The potential contributions of this study are threefold. First, it enriches the literature on the economic consequences of equity pledges via analyzing their impact on corporate innovation. Second, by adopting a micro-level perspective, the study examines how the inherent heterogeneity of managerial risk preference and ability influences enterprise innovation, thereby broadening the scope of research on the drivers of innovation. Third, it identifies and clarifies the mediating and moderating roles of these managerial factors in the relationship between equity pledging and enterprise innovation, offering new empirical insights that deepen our understanding of the internal mechanisms at play.

2. Theoretical Analysis and Research Hypotheses

2.1 Major Shareholders' Equity Pledge and Enterprise Innovation

The equity pledge by major shareholders can affect corporate innovation through multiple channels, primarily by intensifying Type II agency problems, exacerbating financing constraints, and increasing control transfer risks^[6]. In many emerging markets, ownership structures are highly concentrated, often with major shareholders holding a dominant stake. Although equity pledging is formally a personal financial decision of the shareholder, in such contexts it can blur the boundary between personal and corporate interests, thereby weakening incentive alignment and heightening the risk of expropriation^[7]. Given the inherently

uncertainty and long-term nature of innovation activities, major shareholders facing liquidity pressure from pledged shares may adopt short-termism. To safeguard their personal interests, they may avoid committing resources to high-risk R&D investments, thus undermining the firm's innovation efforts^[8]. Moreover, equity pledging often signals the shareholder's own financing constraints. If the firm's R&D activities are not adequately supported due to capital shortages, the momentum and sustainability of innovation efforts are likely to be compromised, leading to diminished innovation outcomes^[8]. Based on this reasoning, the following hypothesis is proposed:

H1: All else being equal, equity pledging by major shareholders is negatively associated with enterprise innovation.

When controlling shareholders pledge their equity, their cash flow rights are substantially diminished while their voting rights remain intact. This divergence between control and ownership leads to a misalignment of interests, often referred to as the separation of cash-flow and control rights^[9]. As the proportion of pledged equity increases, this separation becomes more pronounced, heightening the risk of agency problems. To avoid triggering forced liquidation of their pledged shares, controlling shareholders with high pledge ratios may act more conservatively and tend to curtail risky innovation projects. This behavior reflects a shift in resource allocation strategy, whereby R&D expenditure is adjusted in accordance with the equity pledge ratio, thereby influencing the firm's overall innovation capacity. Based on the above analysis, this study contends that major shareholders' equity pledge ratio serves as a critical transmission channel through which shareholder pledging influences corporate financial decisions and, by extension, innovation performance. Accordingly, the second hypothesis is proposed:

H2: All else being equal, the equity pledge ratio by major shareholders is negatively associated with enterprise innovation.

2.2 The Mediating Role of Managerial Risk Preference

As a critical corporate event, equity pledging by controlling shareholders is not merely a personal financial decision; it also exerts broader organizational influence, particularly on managers' attitudes toward risk and strategic

decision-making. The pledge of major shareholders' equity can affect managerial risk preferences through several mechanisms. First, the increased likelihood of a stock price collapse following an equity pledge may compel managers to adopt a more conservative operational stance. In response to the heightened financial instability, managers may lower their personal risk tolerance to align with the immediate need for corporate stability^[10]. Second, equity pledging signals financial distress, exacerbating the firm's external financing constraints^[11]. As equity-pledged firms typically face greater difficulty in securing refinancing, particularly when major shareholders are already under financial pressure, managers may avoid high-risk, capital-intensive innovation initiatives due to a lack of funding certainty. Third, equity pledges widen the divergence in strategic objectives between shareholders and managers. In such cases, managers may be disincentivized to engage in risk-taking behavior, opting instead for stability over innovation. Based on this reasoning, the third hypothesis is proposed:

H3: All else being equal, equity pledging by major shareholders is negatively associated with managerial risk preference.

Moreover, the effect of equity pledges on enterprise innovation is not necessarily direct. By altering both the internal operating environment and external financing conditions, equity pledges may shape managers' attitudes toward risk, which in turn affects the firm's innovation behavior. Previous research has shown that CEO risk preference is closely tied to decision-making, with risk aversion being a rational response to heightened uncertainty associated with pledged equity^[12,13]. Fang and Liu^[14] identified managerial risk preference as a mediating variable linking CEO personal traits with enterprise R&D expenditure, while Lan^[15] found that managerial risk tolerance positively correlates with enterprise innovation output. Thus, the fourth hypothesis is proposed:

H4: All else being equal, managerial risk preference mediates the relationship between major shareholders' equity pledging and enterprise innovation.

2.3 The Moderating Role of Managerial Ability

Drawing on human capital theory and management theory, first of all, highly capable

managers possess strong professional competencies and psychological resilience, enabling them to withstand greater levels of risk, even in the context of major shareholders' equity pledges. Second, they demonstrate superior cognitive and analytical skills, allowing them to fully evaluate investment projects under foreseeable conditions. This ability empowers them to make forward-looking decisions by accepting lower short-term returns in exchange for potentially higher long-term gains^[16]. Third, competent managers excel in resource integration^[17], stakeholder communication, and cross-functional coordination^[18], which becomes particularly valuable when equity pledging by major shareholders introduces added complexity into relationships with investors, customers, and suppliers.

However, from the perspective of principal-agent theory and cost-benefit theory, the picture is more nuanced. When major shareholders pledge their equity, goal misalignment between shareholders and managers becomes more pronounced. In such circumstances, managers may become risk-averse to protect their personal interests, prioritizing short-term performance to safeguard their reputation, compensation, and job security^[19]. Furthermore, even when capable managers maintain a high-risk appetite and remain willing to engage in R&D and innovation, external constraints such as financing difficulties, resource shortages, performance pressure, or the threat of stock price collapse, can significantly limit their ability to sustain innovation efforts. Given these complex dynamics, the following competing hypotheses are proposed:

H5a: All else being equal, managerial ability positively moderates the mediating effect of managerial risk preference.

H5b: All else being equal, managerial ability negatively moderates the mediating effect of managerial risk preference.

3. Research Design

3.1 Sample Selection and Data Sources

To ensure data comparability and minimize the potential influence of the pandemic, this paper selects A-share listed companies in China over the period from 2008 to 2017 as its research sample. Several data screening procedures are applied. First, firms in the financial sector and those with abnormal or incomplete financial data

are excluded. Second, firms that were designated as ST or *ST during the sample period are excluded. Third, newly listed companies with a listing history of less than one year are removed. To mitigate the influence of outliers, all continuous variables are subjected to Winsorization at the 1st and 99th percentiles. The original data of other financial indicators, including major shareholders' equity pledges and corporate innovation activities, are obtained from the CSMAR database and the RESSET database. Microsoft Excel 2010, Stata 14, DEAP 2.1, and SPSS 20.0 are used in the analysis process.

3.2 Variable Definition

This study incorporates several key variables, including major shareholders' equity pledging, enterprise innovation, managerial risk preference, managerial ability, nature of property rights, shareholding ratio, company size, cash holding, profitability, and other control variables.

(1) Dependent variable: enterprise innovation

Enterprise innovation (*Innovation*) is the dependent variable. Following the research of Simeth and Wehrheim^[20] and Zhang^[2], this study measures enterprise innovation by the annual number of patent applications submitted by listed companies.

$$\begin{aligned} Mrp &= \frac{\text{Total risk assets}}{\text{Total Assets}} = \frac{\text{Short term asset risk} + \text{Long term risk assets}}{\text{Total Assets}} \\ &= \frac{\text{Trading financial assets} + \text{accounts receivable}}{\text{Total Assets}} \\ &+ \frac{\text{Available for sale financial assets} + \text{Held to maturity investment} + \text{investment property}}{\text{Total Assets}} \end{aligned}$$

(4) Moderating variable: managerial ability

Managerial ability (*Ma*) is assessed using a two-stage Data Envelopment Analysis (DEA)–Tobit model, drawing on the methodologies developed by Peter^[24] and Boustanifar^[22], with improvements tailored to the research context.

(5) Control variables

To enhance the robustness of the model, several control variables commonly used in corporate finance and innovation literature are incorporated. These variables include company size (*Size*), cash holding (*Cash*), Return on Assets (*ROA*), debt level (*Lev*), equity concentration (*Cr*), enterprise growth (*Growth*),

(2) Independent variable: equity pledging by major shareholders

The independent variable is the equity pledging by major shareholders, operationalized through two measures (*Pledge1* and *Pledge2*) based on Deshui^[21]. *Pledge1* is a binary indicator denoting whether the major shareholder has pledged equity by the end of the year. This dummy variable equals 1 if a pledge exists, and 0 otherwise. *Pledge2* denotes the equity pledge ratio of the major shareholder, calculated as the proportion of shares pledged to the total number of shares held by the major shareholder at year-end ($\text{Pledge2} = \text{Number of shares pledged by the major shareholder at year-end} / \text{Total shares held by the major shareholder at year-end}$).

(3) Mediating variable: managerial risk preference

Following Boustanifar^[22] and Tulchynska^[23], this study conceptualizes managerial risk preference (*Mrp*) through financial decision-making behaviors. Given the inherent difficulty in measuring risk preference directly, this study adopts an indirect proxy, i.e., the ratio of risk assets to total assets, to quantify a manager's willingness to engage in risk-taking activities.

establishment time (*Age*), Tobin's Q ratio (*TobinQ*), year (*Year*), and industry (*Ind*).

3.3 Model construction

To empirically test the proposed hypotheses, the following models are constructed. Model (1) examines the effect of major shareholders' equity pledging on corporate innovation. Model (2) investigates the relationship between the equity pledge ratio of major shareholders and corporate innovation. Model (3) assesses how the equity pledge ratio of major shareholders influences managers' risk preferences. Finally, Model (4) evaluates the mediating role of managerial risk preference.

$$\begin{aligned} Innovation &= \alpha_0 + \alpha_1 Pledge1 + \alpha_2 Size + \alpha_3 Cash + \alpha_4 Roa + \alpha_5 Lev + \alpha_6 Cr \\ &+ \alpha_7 Growth + \alpha_8 Age + \alpha_9 TobinQ + \alpha_{10} Year + \alpha_{11} Ind + \varepsilon \end{aligned} \quad (1)$$

$$\begin{aligned} Innovation = & \alpha_0 + \alpha_1 Pledge2 + \alpha_2 Size + \alpha_3 Cash + \alpha_4 Roa + \alpha_5 Lev + \alpha_6 Cr \\ & + \alpha_7 Growth + \alpha_8 Age + \alpha_9 TobinQ + \alpha_{10} Year + \alpha_{11} Ind + \varepsilon \end{aligned} \quad (2)$$

$$\begin{aligned} Mrp = & \alpha_0 + \alpha_1 Pledge1 + \alpha_2 Size + \alpha_3 Cash + \alpha_4 Roa + \alpha_5 Lev + \alpha_6 Cr \\ & + \alpha_7 Growth + \alpha_8 Age + \alpha_9 TobinQ + \alpha_{10} Year + \alpha_{11} Ind + \varepsilon \end{aligned} \quad (3)$$

$$\begin{aligned} Innovation = & \alpha_0 + \alpha_1 Pledge1 + \alpha_2 Mrp + \alpha_3 Size + \alpha_4 Cash + \alpha_5 Roa + \alpha_6 Lev \\ & + \alpha_7 Cr + \alpha_8 Growth + \alpha_9 Age + \alpha_{10} TobinQ + \alpha_{11} Year + \alpha_{12} Ind + \varepsilon \end{aligned} \quad (4)$$

To test the moderated mediation effect, this study adopts the step-wise procedure proposed by Haar^[25].

$$\begin{aligned} Innovation = & \alpha_0 + \alpha_1 Pledge1 + \alpha_2 Ma + \alpha_3 Size + \alpha_4 Cash + \alpha_5 Roa + \alpha_6 Lev \\ & + \alpha_7 Cr + \alpha_8 Growth + \alpha_9 Age + \alpha_{10} TobinQ + \alpha_{11} Year + \alpha_{12} Ind + \varepsilon \end{aligned} \quad (5)$$

$$\begin{aligned} Mrp = & \alpha_0 + \alpha_1 Pledge1 + \alpha_2 Ma + \alpha_3 Size + \alpha_4 Cash + \alpha_5 Roa + \alpha_6 Lev \\ & + \alpha_7 Cr + \alpha_8 Growth + \alpha_9 Age + \alpha_{10} TobinQ + \alpha_{11} Year + \alpha_{12} Ind + \varepsilon \end{aligned} \quad (6)$$

$$\begin{aligned} Innovation = & \alpha_0 + \alpha_1 Pledge1 + \alpha_2 Ma + \alpha_3 Mrp + \alpha_4 Size + \alpha_5 Cash + \alpha_6 Roa \\ & + \alpha_7 Lev + \alpha_8 Cr + \alpha_9 Growth + \alpha_{10} Age + \alpha_{11} TobinQ + \alpha_{12} Year \\ & + \alpha_{13} Ind + \varepsilon \end{aligned} \quad (7)$$

$$\begin{aligned} Innovation = & \alpha_0 + \alpha_1 Pledge1 + \alpha_2 Ma + \alpha_3 Mrp + \alpha_4 Ma \times Mrp + \alpha_5 Size + \alpha_6 Cash \\ & + \alpha_7 Roa + \alpha_8 Lev + \alpha_9 Cr + \alpha_{10} Growth + \alpha_{11} Age + \alpha_{12} TobinQ \\ & + \alpha_{13} Year + \alpha_{14} Ind + \varepsilon \end{aligned} \quad (8)$$

4. Empirical Results and Analysis

4.1 Correlation Analysis

To preliminarily examine the relationships among the key variables, Pearson correlation

analysis is conducted. The results are presented in Table 1. As shown, all pairwise correlation coefficients are below 0.5, suggesting that no serious multicollinearity exists among the variables.

Table 1. Pearson Correlation Matrix

	Innovation	Pledge1	Pledge2	Mrp	Ma	Size	Cash	ROA	Lev	Cr	Growth	Age	TobinQ
Innovation	1												
Pledge1	-0.057***	1											
Pledge2	-0.084***	0.836***	1										
Mrp	0.278***	-0.030***	-0.027***	1									
Ma	0.023**	-0.023**	-0.014	0.106***	1								
Size	0.350***	-0.091***	-0.120***	-0.138***	0.011	1							
Cash	0.051***	-0.047***	-0.065***	-0.132***	0.112***	0.046***	1						
ROA	0.119***	-0.036***	-0.057***	0.069***	0.295***	0.039***	0.376***	1					
Lev	0.002	0.032***	0.036***	-0.076***	-0.072***	0.352***	-0.190***	-0.391***	1				
Cr	0.074***	-0.138***	-0.175***	-0.074***	0.109***	0.301***	0.121***	0.152***	0.024**	1			
Growth	-0.016*	0.026***	0.015	0.018*	0.111***	0.042***	0.003	0.168***	0.043***	0.121***	1		
Age	-0.027***	0.066***	0.119***	0.032***	-0.005	0.140***	-0.057***	-0.106***	0.094***	-0.264***	-0.009	1	
TobinQ	-0.072***	0.073***	0.085***	0.102***	0.110***	-0.455***	0.078***	0.154***	-0.298***	-0.155***	-0.014	0.060***	1

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-tailed).

4.2 Regression Analysis

4.2.1 The direct effect of equity pledging on enterprise innovation

The direct relationship between major shareholders' equity pledging and enterprise innovation is mainly reflected by hypotheses H1 and H2, and tested through Model (1) and Model (2). In Model (1), the independent variable is *Pledge1* (whether the major shareholder has pledged equity); in Model (2), the independent

variable is *Pledge2* (the equity pledge ratio of the main shareholder). The regression results are presented in Table 2.

According to the multiple regression results, the coefficient of *Pledge1* in Model (1) is -0.084, which is significantly negative at the 5% level, indicating that the existence of equity pledging by major shareholders has a suppressive effect on enterprise innovation. This finding supports H1. In Model (2), the coefficient of *Pledge2* is -0.181, which is significantly negative at the 1%

level, suggesting that the higher the proportion of equity pledged by major shareholders, the stronger the inhibitory effect on enterprise innovation. H2 is thus verified.

Table 2. Regression Results of Equity Pledging on Enterprise Innovation

Variable	Model (1) <i>Innovation</i>	Model (2) <i>Innovation</i>
<i>Pledge1</i>	-0.084** (-2.348)	
<i>Pledge2</i>		-0.181*** (-3.572)
<i>Size</i>	0.639*** (41.162)	0.636*** (40.899)
<i>Cash</i>	-0.397* (-1.649)	-0.41* (-1.705)
<i>ROA</i>	1.917*** (5.462)	1.916*** (5.462)
<i>Lev</i>	-0.92*** (-9.41)	-0.91*** (-9.314)
<i>Cr</i>	-0.968*** (-8.302)	-0.985*** (-8.448)
<i>Growth</i>	-0.092*** (-3.34)	-0.092*** (-3.32)
<i>Age</i>	-0.577*** (-10.894)	-0.565*** (-10.629)
<i>TobinQ</i>	0.133*** (9.43)	0.134*** (9.458)
<i>Year</i>	Control	Control
<i>Ind</i>	Control	Control
<i>constant</i>	-9.505*** (-28.767)	-9.464*** (-28.635)
<i>F value</i>	229.509***	230.468***
<i>Adj. R²</i>	0.160	0.161

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-tailed); t -values in parentheses.

4.2.2 The mediating effect of managerial risk preference

To test hypotheses H3 and H4, this study adopts the causal stepwise regression approach, employing Model (1), Model (3), and Model (4). Table 3 presents the corresponding results.

The regression results from Model (1), as previously discussed in Section 4.2.1, confirm that controlling shareholders' equity pledging (*Pledge1*) has a significant negative impact on corporate innovation (*Innovation*), supporting H1. The regression outcomes of Model (3) reveal that *Pledge1* is negatively correlated with managerial risk preference (*Mrp*) at the 1% significance level, with a coefficient of -0.011. This finding indicates that equity pledging can notably curb managers' inclination towards

risk-taking, thereby validating H3. According to the regression results from Model (4), although the direct relationship between *Pledge1* and *Innovation* remains negative, it fails to reach statistical significance. However, the mediating variable *Mrp* is found to be positively and significantly associated with *Pledge1*, with a coefficient of 0.695. Combined with the previously established significant negative correlation between *Pledge1* and *Innovation* in Model (1), it can be inferred that managerial risk preference fully mediates the effect of major shareholders' equity pledging on enterprise innovation. Consequently, H4 is also supported. In summary, the findings reveal that the influence of major shareholders' equity pledging on enterprise innovation is predominantly mediated by managerial risk preference. The underlying mechanism follows the logical path: equity pledge by major shareholders → decreased managerial risk preference → reduced corporate innovation. When major shareholders engage in equity pledges, it leads to more risk-averse managerial behavior, which in turn reduces the firm's engagement in high-risk innovation initiatives, ultimately diminishing the overall level of corporate innovation.

Table 3. Test Results for the Mediating Effect of Managerial Risk Preference

Variable	Model (1) <i>Innovation</i>	Model (3) <i>Mrp</i>	Model (4) <i>Innovation</i>
<i>Pledge1</i>	-0.084** (-2.348)	-0.013*** (-5.636)	-0.012 (-0.367)
<i>Mrp</i>			5.31*** (39.479)
<i>Size</i>	0.639*** (41.162)	-0.011*** (-10.156)	0.695*** (47.677)
<i>Cash</i>	-0.397* (-1.649)	-0.284*** (-17.613)	1.111*** (4.869)
<i>ROA</i>	1.917*** (5.462)	0.29*** (12.357)	0.374 (1.133)
<i>Lev</i>	-0.92*** (-9.41)	-0.002 (-0.363)	-0.907*** (-9.93)
<i>Cr</i>	-0.968*** (-8.302)	-0.02** (-2.546)	-0.862*** (-7.911)
<i>Growth</i>	-0.092*** (-3.34)	0.001 (0.628)	-0.098*** (-3.813)
<i>Age</i>	-0.577*** (-10.894)	0.017*** (4.774)	-0.667*** (-13.458)
<i>TobinQ</i>	0.133*** (9.43)	0.003*** (3.148)	0.118*** (8.887)
<i>Year</i>	Control	Control	Control
<i>Ind</i>	Control	Control	Control

<i>constant</i>	-9.505*** (-28.767)	0.358*** (16.185)	-11.407*** (-36.496)
<i>F value</i>	229.509***	75.187***	392.311***
<i>Adj. R²</i>	0.160	0.058	0.266

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-tailed); t -values in parentheses.

4.2.3 Moderated mediation model: the role of managerial ability

After establishing the links between equity pledging by major shareholders, managerial risk preference, and enterprise innovation, this section introduces managerial ability, an important internal characteristic of managers, as a moderating variable to further explore the conditional mechanism of the mediating process. This analysis adopts the moderated mediation testing approach proposed by Ted^[26], and conducts a stepwise regression using Models (5) to (8). The corresponding results are listed in Table 4.

In Model (5), enterprise innovation (*Innovation*) is regressed on equity pledging by major shareholders (*Pledge1*) and managerial ability (*Ma*). The coefficient for *Pledge1* is -0.084,

significant at the 5% level, indicating that equity pledging by major shareholders continues to exert a significant negative effect on enterprise innovation. In Model (6), managerial risk preference (*Mrp*) is regressed on *Pledge1* and *Ma*. The coefficient for *Pledge1* is -0.013, significant at the 1% level, demonstrating that equity pledging significantly restrains managerial risk preference. In Model (7), *Innovation* is regressed on *Pledge1*, *Ma*, and *Mrp*. The coefficient for *Mrp* is 5.36, significant at the 1% level, indicating that managerial risk preference positively influences innovation, confirming the mediating effect remains statistically robust when the moderator is included. In Model (8), the interaction term between managerial ability and managerial risk preference ($Ma \times Mrp$) is added to examine the moderating effect. The interaction term yields a coefficient of -3.696, significant at the 1% level, indicating a negative moderating effect. This suggests that managerial ability plays a negative role in the moderated mediation model. Accordingly, H5b is verified, while H5a is rejected.

Table 4. Test Results of the Moderated Mediation Model

Variable	Model (5)	Model (6)	Model (7)	Model (8)
	<i>Innovation</i>	<i>Mrp</i>	<i>Innovation</i>	<i>Innovation</i>
<i>Pledge1</i>	-0.084** (-2.355)	-0.013*** (-5.512)	-0.014 (-0.41)	-0.015 (-0.464)
<i>Ma</i>	-0.071 (-0.47)	0.095*** (9.43)	-0.58*** (-4.097)	-0.073 (-0.339)
<i>Mrp</i>			5.36*** (39.717)	5.433*** (39.689)
$Ma \times Mrp$				-3.696*** (-3.121)
<i>Size</i>	0.639*** (41.15)	-0.01*** (-10.064)	0.695*** (47.689)	0.695*** (47.686)
<i>Cash</i>	-0.397* (-1.648)	-0.284*** (-17.689)	1.126*** (4.936)	1.109*** (4.863)
<i>ROA</i>	1.958*** (5.411)	0.235*** (9.728)	0.7** (2.06)	0.752** (2.214)
<i>Lev</i>	-0.917*** (-9.367)	-0.006 (-0.914)	-0.885*** (-9.679)	-0.869*** (-9.488)
<i>Cr</i>	-0.963*** (-8.238)	-0.026*** (-3.298)	-0.825*** (-7.554)	-0.808*** (-7.393)
<i>Growth</i>	-0.092*** (-3.31)	0 (0.123)	-0.093*** (-3.591)	-0.094*** (-3.619)
<i>Age</i>	-0.576*** (-10.866)	0.016*** (4.417)	-0.66*** (-13.314)	-0.658*** (-13.271)
<i>TobinQ</i>	0.134*** (9.436)	0.002** (2.38)	0.122*** (9.19)	0.124*** (9.309)
<i>Year</i>	Control	Control	Control	Control

Ind	Control	Control	Control	Control
constant	-9.512*** (-28.76)	0.367*** (16.635)	-11.479*** (-36.695)	-11.504*** (-36.779)
F value	206.565***	77.113***	358.695***	329.883***
Adj. R ²	0.160	0.066	0.268	0.268

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-tailed); t -values in parentheses.

4.3 Robustness Tests

This study conducts a series of robustness tests from the following three perspectives.

4.3.1 Alternative variable specification

To verify the consistency of the results, this section replaces the binary variable indicating whether major shareholders engaged in equity

pledging (*Pledge1*) with the equity pledge ratio of major shareholders (*Pledge2*) in Models (3) to (8). The updated regression results are detailed in Table 5. It is evident that the findings from this substitution align with the previously derived conclusions.

Table 5. Test Results Using *Pledge2* Instead of *Pledge1*

Variable	Model (2) <i>Innovation</i>	Model (3) <i>Mrp</i>	Model (4) <i>Innovation</i>	Model (5) <i>Innovation</i>	Model (6) <i>Mrp</i>	Model (7) <i>Innovation</i>	Model (8) <i>Innovation</i>
<i>Pledge2</i>	-0.181*** (-3.572)	-0.021*** (-6.184)	-0.07 (-1.469)	-0.181*** (-3.572)	-0.021*** (-6.211)	-0.069 (-1.447)	-0.071 (-1.496)
<i>Ma</i>				-0.065 (-0.433)	0.096*** (9.521)	-0.578*** (-4.084)	-0.069 (-0.319)
<i>Mrp</i>			5.301*** (39.404)			5.352*** (39.64)	5.424*** (39.617)
<i>Ma</i> × <i>Mrp</i>							-3.714*** (-3.137)
<i>Size</i>	0.639*** (41.162)	-0.011*** (-10.368)	0.694*** (47.449)	0.636*** (40.888)	-0.011*** (-10.284)	0.693*** (47.466)	0.693*** (47.461)
<i>Cash</i>	-0.397* (-1.649)	-0.285*** (-17.677)	1.101*** (4.821)	-0.41* (-1.704)	-0.285*** (-17.759)	1.116*** (4.89)	1.099*** (4.816)
<i>ROA</i>	1.917*** (5.462)	0.29*** (12.347)	0.378 (1.144)	1.954*** (5.402)	0.234*** (9.698)	0.702** (2.068)	0.755** (2.222)
<i>Lev</i>	-0.92*** (-9.41)	-0.002 (-0.283)	-0.901*** (-9.855)	-0.908*** (-9.273)	-0.005 (-0.83)	-0.879*** (-9.609)	-0.862*** (-9.417)
<i>Cr</i>	-0.968*** (-8.302)	-0.021*** (-2.659)	-0.875*** (-8.024)	-0.981*** (-8.385)	-0.027*** (-3.431)	-0.838*** (-7.66)	-0.821*** (-7.498)
<i>Growth</i>	-0.092*** (-3.34)	0.001 (0.608)	-0.098*** (-3.782)	-0.091*** (-3.292)	0 (0.104)	-0.092*** (-3.563)	-0.093*** (-3.591)
<i>Age</i>	-0.577*** (-10.894)	0.018*** (5.104)	-0.661*** (-13.292)	-0.564*** (-10.604)	0.017*** (4.751)	-0.654*** (-13.153)	-0.652*** (-13.108)
<i>TobinQ</i>	0.133*** (9.43)	0.003*** (3.129)	0.118*** (8.924)	0.134*** (9.462)	0.002** (2.36)	0.122*** (9.224)	0.124*** (9.343)
<i>Year</i>	Control	Control	Control	Control	Control	Control	Control
<i>Ind</i>	Control	Control	Control	Control	Control	Control	Control
constant	-9.505*** (-28.767)	0.36*** (16.268)	-11.373*** (-36.364)	-9.47*** (-28.626)	0.369*** (16.734)	-11.446*** (-36.565)	-11.472*** (-36.65)
F value	229.509***	75.95	392.587	207.424	77.99	358.934	330.113
Adj. R ²	0.160	0.059	0.267	0.161	0.067	0.268	0.268

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-tailed); t -values in parentheses.

4.3.2 Noise mitigation in the measurement of managerial ability

Previous studies have noted that the residuals from the second-stage Tobit model may not fully isolate managerial ability due to unobserved

enterprise-level efficiency factors, thereby introducing measurement noise (Li ^[27]). To address this concern, this study follows the method of He ^[28] by transforming the residual-based managerial ability score into a

discrete categorical variable (*Ma2*). Specifically, residuals are ranked and grouped into ten levels, with values assigned from 1 to 10, representing increasing levels of managerial ability. Subsequently, the causal stepwise regression is re-run using *Ma2* in place of the original continuous measure in Models (5) to (8). The results are displayed in Table 6, and they continue to support the previously established findings.

4.3.3 Bootstrap test

To further verify the robustness of the mediating

and moderated mediating effects, this study applies the bias-corrected nonparametric percentile Bootstrap method. The Bootstrap method evaluates the significance of effects by examining whether the 95% confidence interval (CI) includes zero. If the CI excludes zero, the effect is considered statistically significant; otherwise, it is not. In this test, 5000 bootstrap samples are drawn. Model (4) and Model (8) are selected to test the mediating effect and the moderated mediating effect, respectively. The results are reported in Table 7.

Table 6. Test Results Using *Ma2*

Variable	Model (5)	Model (6)	Model (7)	Model (8)
	<i>Innovation</i>	<i>Mrp</i>	<i>Innovation</i>	<i>Innovation</i>
<i>Pledge1</i>	-0.084** (-2.37)	-0.013*** (-5.499)	-0.014 (-0.429)	-0.016 (-0.483)
<i>Ma2</i>	-0.008 (-1.281)	0.004*** (8.769)	-0.027*** (-4.717)	-0.001 (-0.095)
<i>Mrp</i>			5.364*** (39.775)	6.423*** (20.741)
<i>Ma2</i> × <i>Mrp</i>				-0.177*** (-3.797)
<i>Size</i>	0.639*** (41.129)	-0.01*** (-10.013)	0.694*** (47.664)	0.695*** (47.709)
<i>Cash</i>	-0.396* (-1.645)	-0.284*** (-17.703)	1.13*** (4.955)	1.112*** (4.88)
<i>ROA</i>	2.03*** (5.61)	0.239*** (9.891)	0.748** (2.205)	0.798** (2.352)
<i>Lev</i>	-0.912*** (-9.313)	-0.006 (-0.908)	-0.88*** (-9.625)	-0.862*** (-9.419)
<i>Cr</i>	-0.954*** (-8.153)	-0.026*** (-3.334)	-0.814*** (-7.449)	-0.797*** (-7.287)
<i>Growth</i>	-0.091*** (-3.271)	0 (0.184)	-0.092*** (-3.574)	-0.093*** (-3.584)
<i>Age</i>	-0.574*** (-10.813)	0.015*** (4.329)	-0.656*** (-13.228)	-0.654*** (-13.183)
<i>TobinQ</i>	0.135*** (9.506)	0.002** (2.364)	0.123*** (9.272)	0.125*** (9.388)
<i>Year</i>	Control	Control	Control	Control
<i>Ind</i>	Control	Control	Control	Control
<i>constant</i>	-9.481*** (-28.65)	0.347*** (15.722)	-11.344*** (-36.296)	-11.529*** (-36.47)
<i>F value</i>	206.734	75.836	359.374	331.038
<i>Adj. R²</i>	0.16	0.065	0.268	0.269

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-tailed); t -values in parentheses.

Table 7. Bootstrap Test Results for the Mediating Effect of Managerial Risk Preference

Effect Category	<i>Pledge1</i> →	<i>Mrp</i> →	<i>Innovation</i>
	Effect	BootSE	BootLLCI
Total	-0.0835	0.0356	-0.1532
Direct	-0.0122	0.0333	-0.0775
Indirect	-0.0713	0.0128	-0.0963

The CI for the mediating effect (Indirect) is [-0.0963, -0.0458], which does not contain zero, indicating that the mediating effect is statistically significant (Effect = -0.0713). The CI for the total effect (Total) is [- 0.152, -0.0138], also excluding zero, which confirms that the total effect is significant (Effect = -0.0835). However, the CI for the direct effect (Direct) is [- 0.0775, 0.0531], which includes zero, suggesting that the direct effect is not significant. Based on these results, it can be concluded that managerial risk preference (*Mrp*) fully mediates the relationship between major shareholder equity pledging (*Pledge1*) and corporate innovation (*Innovation*). This finding echoes the earlier conclusions obtained through stepwise regression, thereby providing additional support for H1 and H4.

To further assess the moderating role of managerial ability (*Ma*) in the relationship between *Mrp*, *Pledge1*, and *Innovation*, this study conducts a Bootstrap analysis at three distinct levels of *Ma*: 1) low (one standard

deviation below the mean, $M - 1SD$), 2) medium (at the mean, M), and 3) high (one standard deviation above the mean, $M + 1SD$). The results are summarized in Table 8.

When *Ma* is low, the 95% Bootstrap CI for the mediating effect is [-0.1068, -0.0509], with an effect size of -0.0786, demonstrating the significance of the effect. At the medium level, the CI is [-0.0981, -0.0475], with an effect size of -0.0729, again confirming significance. When *Ma* is high, the CI is [-0.091, -0.0436], with an effect size of -0.0671, demonstrating continued significance.

In all three cases, the CIs do not include zero, which strongly suggests that the indirect effect remains significant across varying levels of managerial ability. Moreover, the decreasing magnitude of the effect as *Ma* increases implies a negative moderating influence. Overall, these findings provide robust support for H5b, confirming its validity.

Table 8. Bootstrap Test Results for the Moderated Mediating Effect

Effect	Moderating variable (<i>Ma</i>)		<i>Pledge1</i> —→ <i>Mrp</i> —→ <i>Innovation</i>			
	Level	Value	Effect	BootSE	BootLLCI	BootULCI
Indirect	<i>Ma</i> ($M-1SD$)	-0.1147	-0.0786	0.0143	-0.1068	-0.0509
	<i>Ma</i> (M)	0.0013	-0.0729	0.013	-0.0981	-0.0475
	<i>Ma</i> ($M+1SD$)	0.1172	-0.0671	0.0121	-0.091	-0.0436

5. Conclusion

The study yields several key findings. First, equity pledges made by major shareholders significantly inhibit corporate innovation, with the magnitude of this effect increasing as the proportion of pledged equity rises. Second, major shareholders' equity pledging is found to be negatively associated with managerial risk preference. Additionally, managerial risk preference fully mediates the relationship between equity pledging and enterprise innovation. Third, based on a moderated mediation model, the analysis confirms that managerial ability negatively moderates the mediating effect of managerial risk preference. This study explores the mechanism through which agency issues induced by major shareholders' equity pledging impact enterprise innovation, with particular attention given to the role of managerial heterogeneity as an underlying factor. By examining this relationship, the study seeks to generate insights that support corporate innovation from both ownership and managerial perspectives, thereby enriching the

broader understanding of innovation-driven corporate strategies.

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