Enterprise Risk Bearing Tendency, Management Technical Background, and R&D Investment

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Abstract. We studied the impact of corporate risk-taking propensity on R&D investment, as well as the impact of management's technical background on the relationship between corporate risk-taking propensity and R&D investment. Our investigation motivation is the potential issue of mismatch between innovation input and innovation output in China in recent years. We examined the impact of enterprise risk taking propensity on the intensity and variability of R&D investment, and found that an increase in enterprise risk taking can significantly promote the intensity of R&D investment and reduce the variability of R&D investment. In addition, we also found that the improvement of the management's technical background will enhance the positive impact of the enterprise's risk taking tendency and R&D investment intensity, as well as the negative impact on the variability of R&D investment. We conducted extensive robustness tests on our results, and among all these tests, our results were robust.

Keywords: Risk taking tendency; Technical background of the management team; R&D inve-stment.

1. Introduction

At present, despite the overall improvement of China's innovation level, there are still significant development risks. Although the growth rate of innovation investment in China has reached 12.3% in the past five years, far surpassing developed countries such as the United States (7.8%), Japan (1.0%), and Germany (3.5%), there are potential problems that are difficult to match with the innovation output index. The long-term mismatch problem may lead to chronic problems such as weak growth in innovation output.

Existing studies have shown that there is a significant positive correlation between enterprise risk taking and R&D investment of Chinese enterprises[1]. Therefore, it is a question that requires further empirical testing to find whether the increase in risk taking tendencies of enterprises can promote R&D investment.

In addition, an excessively high level of risk will pose a threat to the sustainable operation of the enterprise. Therefore, how to bring more R&D investment while appropriately increasing the overall risk of the enterprise has become another issue that needs to be considered.

This article introduces the technical background of management into the relationship between enterprise risk taking and R&D investment. Firstly, it empirically examines the relationship between enterprise risk taking propensity and R&D investment, and then explores the impact of management's technical background on the relationship between the two. It is hoped that the two questions raised above can be answered.

The rest of this article is organized as follows. Section 2 reviewed the previous research on enterprise risk taking tendencies, management technical background, and R&D investment. Section 3 is the theoretical framework and research hypotheses. Section 4 describes the regression model and the methods used to estimate the model. Section 5 introduces the empirical results. Section 6 discusses the meaning of this article and summarizes it.

2. Literature review

2.1. The influencing factors and economic consequences of R&D investment

2.1.1 The influencing factors of R&D investmen

The influencing factors of R&D investment can be divided into two aspects: internal influencing factors and external influencing factors.

The internal influencing factors of R&D investment mainly include business status, company size, corporate governance, and management characteristics. The good operating conditions of enterprises have a significant positive promoting effect on R&D[1]. The expansion of enterprise scale can stimulate the level of R&D investment in enterprises, and thus further promote the improvement of innovation performance. Rodrigues et al. (2020) have demonstrated that appropriate governance mechanisms have positive implications for enhancing the level of R&D investment in enterprises. In terms of management characteristics, age, personal personality, personal experience, and tenure are all significant variables that affect a company's R&D investment[4-7].

The external influencing factors of R&D investment mainly include political environment, monetary policy, tax policy, and industry characteristics. Liu Meng and Yang Qing (2022) found that talent policies have an incentive effect on enterprise innovation. Ren Shuming et al. (2021) found that the increase in monetary policy uncertainty significantly inhibits corporate innovation. De, Perote & Gabriel et al. (2022) found that higher economic policies and tighter monetary policies will have a significant positive impact on R&D investment. The research results of Zhuang Yumei and Wang Li (2022) indicate that industry competition, technology intensity, and government fiscal and tax policies can all drive technological innovation in technology enterprises, and fiscal subsidies have a more significant promoting effect on technological innovation than tax incentives.

2.1.2 The Economic Consequences of R&D Investment

The economic effects of enterprise R&D investment are mainly reflected in the direct improvement of innovation output and regional innovation capacity, as well as the indirect improvement of enterprise performance and total factor productivity. Ba Shusong, Wu Lili, and Xiong Peihan (2022) empirically analyzed the impact of R&D investment on enterprise innovation output through static and dynamic panel models. The results showed that increasing the level of R&D investment can effectively improve enterprise innovation performance; Zhang Chunhong (2019) studied the impact of innovation capability and R&D investment in various provinces, and empirical evidence shows that an increase in R&D investment level of regional enterprises will significantly promote regional innovation capability. Zhu Tao, Li Junshan and Zhu Linran (2022) studied the relationship between manager characteristics, R&D investment, and corporate performance. Empirical evidence shows that R&D investment significantly promotes the improvement of corporate performance, and R&D investment is a mediating variable between manager characteristics and corporate performance; Ren Yuxin et al. (2022) explored the mechanism of government subsidies, R&D investment, and total factor productivity. The study showed that enterprise R&D investment has a positive promoting effect on total factor productivity, and equity concentration has a significant positive moderating effect between R&D investment and total factor productivity. Wang, Zhang & Li (2020) studied coastal listed companies in China and found that R&D investment has a significant promoting effect on total factor productivity. At the same time, the promoting effect of R&D investment on total factor productivity varies depending on the nature of property rights, degree of financing constraints, and level of marketization.

2.2. The influencing factors and economic consequences of enterprise risk taking

2.2.1 The influencing factors of enterprise risk taking

The main influencing factors of enterprise risk taking include management characteristics, equity structure, corporate governance, and macro political environment. Peltom ä ki et al. (2021) studied the impact of age and gender of corporate executives on corporate risk taking, and found that

companies led by women or older individuals tend to be more inclined towards lower levels of risk taking. Wang Meiying et al. (2020) studied the impact of multiple major shareholders on corporate risk taking based on the background of mixed ownership. Research has found that the existence of multiple major shareholders in the equity structure is more conducive to promoting enterprises to improve their risk taking level. Xiong Yi and Hong Hong (2022) investigated the impact of employee compensation competitiveness on enterprise risk taking, and the results showed that increasing employee compensation can significantly improve the risk taking tendency of enterprises. Zhao Can, Liu Qiren, and Yuan Jin (2022) examined the impact of tax incentives on corporate risk taking, and found that tax incentives significantly enhance corporate risk taking through mechanisms that alleviate financing constraints.

2.2.2 Economic consequences of enterprise risk taking

There is relatively little research on the economic consequences of enterprise risk taking, mainly in terms of promoting long-term development and innovation. Bargeron, Lehn&Zutter (2010) argue that an increase in corporate risk taking will promote capital expenditures. Shang Hongtao and Fang Dan (2021) explore the relationship between government subsidies, risk taking, and innovation, and empirical evidence shows that enterprise risk taking can promote technological innovation. Among them, there is a significant lag in the positive impact of risk taking tendency on the quantity and quality of enterprise innovation.

3. Theoretical framework and hypotheses

3.1. Enterprise Risk Bearing Tendency and R&D Investment

3.1.1 Enterprise Risk Bearing Tendency and R&D Investment Intensity

The management has a unique risk taking tendency. No individual is an absolute risk averse or risk-taker. When faced with risk decisions, their love and aversion towards risk will naturally form a dynamic balance, which is reflected externally and is the individual's risk taking inclination. Therefore, every decision-maker in the management team should have their own unique risk taking tendency. In the process of enterprise operation and development, each manager in the management team is in their respective positions, responsible for formulating plans, providing opinions, supervising management, or making decisions. In the process of fulfilling their duties, it is inevitable that they influence and constrain each other, jointly affecting the development direction of the enterprise. The risk taking tendency of each manager will affect the decision-making of the enterprise during this process, ultimately reflected in the risk tendency of the enterprise's operational decisions and strategic formulation, forming the overall risk taking tendency of the enterprise.

Enterprise R&D projects generally have characteristics such as long cycles, high returns, and risks. On the one hand, based on the uncertain future, the likelihood of R&D projects bringing acceptable benefits is uncertain[22]. Firstly, the final output of research and development projects may not necessarily meet the expectations and market demands of the enterprise, bringing benefits to the enterprise. Secondly, due to its inherent external characteristics, research and development results are easy to replicate, and research and development investment may far exceed the economic benefits brought by output[23]. A large amount of enterprise resources cannot be maximized.

Even more so, there is a potential for catastrophic disasters such as preemptive research and development results during the research and development process, which will result in the long-term investment of a large amount of resources by enterprises being wasted. On the other hand, a large amount of research and development investment also poses significant risks to the normal operation of the entire enterprise. Long term and stable occupation of R&D resources may lead to a shortage of operating resources for enterprises, and even ultimately result in the inability of enterprises to maintain their own normal business activities[24].

The propensity of enterprises to bear risks has a profound impact on the intensity of R&D investment. On the one hand, the tendency of enterprises to bear risks will affect the process of

balancing project returns and risks, and will affect the investment choices of enterprises for high-risk projects. Existing studies have shown that when making decisions, management will inevitably weigh the implementation risks, expected benefits, and other factors of the project[25]. When the risk taking tendency of enterprises is relatively weak, management tends to be more cautious in making risk avoidance choices and adopt a negative approach to deal with high-risk projects[26]. Therefore, in the process of balancing risk and return, the risk taking tendency of enterprises will greatly affect their decision-making in project selection. In the decision-making of individual projects, a low risk taking tendency may result in the abandonment of research and development projects that should have been carried out due to their high risk. On the other hand, the tendency of enterprise risk taking reflects the management's willingness to take on the overall risk of the enterprise. Rational managers, based on the business philosophy of "balancing risk", will control the overall risk of the enterprise at an acceptable expected level. In the overall risk management process of the enterprise, the lower the risk taking tendency of the enterprise, the higher the level of risk aversion and tolerance of the enterprise management[28]. Not willing to bear the excess risk brought about by seeking potential development opportunities outside of normal business activities. Therefore, when the risk taking tendency of a company is low, the overall acceptable level of risk for managers is low. As a high-risk R&D investment, it will inevitably be disliked by the management in the process of balancing risks. The risk taking tendency of enterprises will limit the overall investment in R&D projects, making it difficult for enterprises to invest more in the entire R&D aspect, leading to a lower level of R&D investment intensity. When a company has a high risk taking tendency, the management's tolerance for risk increases. Considering the economic impact of R&D investment on promoting product upgrades, enhancing corporate reputation, and enhancing long-term competitive strength, the intensity of R&D investment will increase. Based on the above analysis, this article proposes the following assumptions:

H1: There is a positive correlation between the risk taking tendency of enterprises and the intensity of R&D investment.

3.1.2 Enterprise Risk Bearing Tendency and R&D Investment Variability

Due to the instability of objective factors, there is a certain degree of variability in the R&D investment of enterprises. Previous studies have shown that the volatility of R&D investment is mainly due to the dependence of R&D investment sources on internal financing. Due to the high risk and information asymmetry of R&D investment, external financing is much more difficult than internal financing, which makes R&D investment extremely sensitive to the impact and fluctuations of some objective factors[29]. The performance level[1], expected income level[30], monetary policy[9], tax policy[31] of enterprises all have a significant impact on their R&D investment. Therefore, when objective factors such as the operating conditions and external environment of a company change, the amount of R&D investment of the company will also fluctuate accordingly.

The tendency of enterprises to bear risks has an impact on the volatility of R&D investment amounts. The impact of performance level, expected returns, monetary policy, tax policy, and other factors on the amount of R&D investment actually affects the risk selection of enterprises from the perspective of risk and returns. The tendency of enterprise risk taking belongs to the subjective preference of management, which is determined by the personal personality, growth background, educational background, and other factors of each decision-making participant, and is less influenced by objective factors of the enterprise. Different risk propensities make enterprises exhibit different responses when facing changes in objective factors.

On the one hand, when a company has a lower level of risk propensity, it indicates that the company's attitude towards risk is in a relatively fearful state, and its sensitivity to risk will also be higher. In the face of deteriorating objective factors, changes in objective factors will prompt companies to adjust their investment in research and development projects to quickly respond to potential business crises such as declining performance and tightening monetary policy. When a company has a high risk taking tendency, even if objective factors deteriorate, it is still possible for the company to have a positive attitude towards risk. Considering the potential benefits of existing

R&D projects that have already invested a large amount of resources in the early stage and the high sunk costs associated with reducing R&D investment[29], it is possible to risk a certain amount of excess risk, maintain the original R&D investment or experience a relatively small contraction, To ensure the stable investment of R&D resources and the timely output of R&D projects. At this point, the fluctuations in enterprise R&D investment caused by objective factors will weaken.

On the other hand, based on the assumption that H1 is established, the higher the risk taking tendency of enterprises, the greater the intensity of R&D investment. For enterprises with the same investment opportunities, in an ideal state, enterprises with a high risk taking tendency should choose R&D projects with NPV>0 as much as possible within the minimum factor limit. In addition to the smallest factor changes, when other objective factors of the enterprise develop in a direction that is beneficial to the enterprise, under the constraints of restrictive resources, enterprises with higher risk taking tendencies have limited space to increase their R&D investment., Enterprises with lower risk taking tendencies still have some R&D projects that should have been invested but not invested in. When the objective factors of the enterprise develop in a direction that is beneficial to the enterprise, in the process of balancing risk returns and risks, more R&D projects will be made through management decisions, and the amount of R&D investment of the enterprise will also increase accordingly. Compared to enterprises with higher risk taking tendencies, when the objective factors of the enterprise improve, the R&D investment of enterprises with lower risk taking tendencies changes more.

In summary, enterprises with lower risk taking tendencies have greater variability in R&D investment compared to enterprises with higher risk taking tendencies. Based on the above analysis, this article proposes the following assumptions:

H2: There is a negative correlation between the risk taking tendency of enterprises and the variability of R&D investment.

3.2. Enterprise Risk Bearing Tendency, Management Technical Background, and R&D Investment

The positive impact of the increase in risk taking tendency of enterprises on the intensity of R&D investment is mainly based on the increase in the overall risk acceptance level of enterprises, which leads to investment in some R&D projects that may be abandoned at low risk taking tendencies. The intensity of R&D investment increases uniformly with the increase in overall risk level. However, in terms of the selection of specific risk projects, the increase in risk taking tendency did not affect the risk taking preference of management.

The management background will divide the decision-making behavior of the management. Based on the theory of bounded rationality and the theory of executive echelons, corporate management is not a "completely rational economic person", and their cognition is limited. The way they think about problems will be influenced by existing cognition, values, and thinking patterns[32]. The age, professional experience, educational background, and social relationships of enterprise management can all affect their cognition, values, and thinking patterns to a certain extent. The one-sided experience of receiving information will also divide the subjective processing process of objective information by management[33], which in turn affects the choices of management in enterprise management decisions.

The management team with strong technical background characteristics has a strong R&D willingness and ability. Previous studies have shown a positive correlation between the professional background of company executives and the company's long-term strategy[34]. Higher technological capabilities typically guarantee higher R&D returns, reduce uncertainty in R&D investment, and broaden the scope of R&D investment. Therefore, enterprises with stronger technological background characteristics will pay more attention to their technological research and innovation activities[35] and are more willing to invest in technical work[36]. We also hold more attention to product production, equipment upgrades, and process updates[37]. At the same time, management with strong technical background characteristics are more likely to identify potential opportunities hidden in

R&D projects and make more accurate evaluations and decisions on R&D projects[38]. In contrast, based on the principal-agent theory and the manager's defense theory, executives with management science backgrounds tend to be more conservative in R&D project decision-making due to insufficient cognition, and instead choose to improve corporate performance through short-term investment, cost control, human resource management, marketing, and other aspects, consolidate their own position and reputation, and maintain and improve their own salary level[39].

The technical background of the management has strengthened their preference for research and development projects[40]. According to a survey based on 'where to use additional internal funds', companies with stronger technological backgrounds are more likely to use additional funds for research and development investments[41]. Therefore, compared to management with strong scientific background characteristics, management with stronger technical background characteristics are more likely to invest additional resources brought about by increased risk taking tendencies in R&D projects when making investment decisions, allowing enterprises to increase their R&D investment intensity while appropriately enhancing their overall risk level. In other words, the positive impact of enterprise risk taking tendency on the intensity of R&D investment will be strengthened. Based on the above analysis, this article proposes the following assumptions:

H3.1 The technical background of the management team positively promotes a positive correlation between the risk taking tendency of enterprises and the intensity of R&D investment.

The technical background of the management also has an impact on the variability of research and development investment. On the one hand, when a company has a lower level of risk propensity, and the objective factors it faces worsen, due to the increase in management's technical background, the company will be more adept at R&D projects. Compared to companies with weaker technological backgrounds, they are more inclined to increase their R&D investment and seek more development opportunities by placing hope on R&D projects to help companies cope with risks. On the contrary, when a company has a high level of risk propensity, as the technological background increases, the management of the company should have more confidence in R&D projects and be able to better maintain the existing R&D investment. At the same time, in an ideal state, high-risk enterprises have adopted all R&D projects with NPV>0 as much as possible, and seeking new and suitable R&D projects still requires some time. In summary, when objective factors are unfavorable and adjusted by the technical background of the management, the change in R&D investment of enterprises with low risk bearing tendencies will be greater, while the change in R&D investment of enterprises with high risk bearing tendencies will be smaller.

On the other hand, based on hypothesis H3.1, the technical background of management will promote a positive correlation between the risk taking tendency of enterprises and the intensity of R&D investment. When the risk taking tendency of enterprises is at a high level, compared to enterprises with weaker management technical background, enterprises with stronger management technical background will have a greater R&D investment intensity. Due to the limitations of minimal factors, there will be even more limited room for the increase in research and development investment for the improvement of other objective factors. For enterprises with lower risk taking tendencies, compared to those with weaker management technical backgrounds, when objective factors are favorable for the transformation of the enterprise, enterprises with stronger management technical backgrounds have stronger technical capabilities and technology absorption capabilities[42]. Compared to companies with weaker management technical backgrounds, the expected risk level of the same R&D project will be lower, so companies will be more proactive in conducting more R&D exploration. Therefore, when the technical background of the enterprise's management is stronger, facing favorable changes in objective factors, the change in R&D investment of enterprises with low risk bearing tendencies will be greater, while the change in R&D investment of enterprises with high risk bearing tendencies will be smaller.

In summary, regardless of whether the objective factors affecting the fluctuation of enterprise R&D investment are favorable or unfavorable changes, the stronger the management's technical background, the more stable the R&D investment of enterprises with high risk bearing tendencies,

and the greater the changes in enterprises with low risk bearing tendencies. Based on this, this article proposes the following assumptions:

H3.2 The technical background of the management has strengthened the negative correlation between the enterprise's risk taking tendency and the variability of research and development investment.

4. Methodology

4.1. The data

This article takes A-share listed companies on the Shanghai and Shenzhen stock markets from 2012 to 2022 as the research object. The raw data mainly comes from the Guotai An database. This article conducts data screening in the following order and standards: (a) Excluding ST and ST* type enterprises. (b) Excluding financial and insurance companies. (c) Eliminate samples with missing data. (d) The available redundancy in the dependent variable, explanatory variable, moderating variable, and control variable was reduced at the 1% and 99% levels of the distribution. In the end, 15715 research samples were obtained in this article. This article selects Stata17.0 to organize, statistically analyze, and analyze relevant data.

4.2. Model and variables

$$R\&D\ power_{i,t}=\beta_0+\beta_1 RT_{i,t}+\beta_2 Gov_{i,t}+\beta_3 Balance_{i,t}+\beta_4 Roa_{i,t}+\beta_5 Num_{i,t}+\beta_6 Age_{i,t}+\beta_7 Slack_{i,t}+\beta_8 Lev_{i,t}+\beta_9 Der_{i,t}+\beta_{10} Man_{i,t}+\sum YEAR+\sum IND+\varepsilon_{i,t} \quad (1)$$

This article constructs model (1) to explore whether the propensity of enterprise risk taking will have an impact on the intensity of enterprise R&D investment. R&D $power_{i,t}$ is measured by dividing the R&D investment amount of a company by the average total assets of the company, while $RT_{i,t}$ is measured by the standard deviation of the daily stock returns of the sample company during the year. Perform regression analysis on the model and observe the sign and significance level of the regression coefficients of $RT_{i,t}$. If $\beta_1 > 0$ indicates that the tendency of enterprises to bear risks will increase the intensity of R&D investment; If $\beta_1 < 0$ indicates that the enterprise's risk taking tendency will weaken the intensity of R&D investment. When the regression coefficient is significant at a statistical level of at least 10%, it indicates that the impact of enterprise risk propensity on R&D investment intensity is significant, and the research results have statistical significance. If H1 holds, then $\beta_1 > 0$.

$$R\&D\ variability_{i,t}=\beta_0+\beta_1 RT_{i,t}+\beta_2 Gov_{i,t}+\beta_3 Balance_{i,t}+\beta_4 Roa_{i,t}+\beta_5 Num_{i,t}+\beta_6 Age_{i,t}+\beta_7 Slack_{i,t}+\beta_8 Lev_{i,t}+\beta_9 Der_{i,t}+\beta_{10} Man_{i,t}+\sum YEAR+\sum IND+\varepsilon_{i,t} \quad (2)$$

This article constructs model (2) to explore whether the propensity of enterprise risk taking will have an impact on the variability of enterprise R&D investment. R&D $variability_{i,t}$ uses the coefficient of variation of R&D investment in the past four years (including this year) of the sample as the R&D variability sample value for the current year. Perform regression analysis on the model and observe the sign and significance level of the regression coefficients of $RT_{i,t}$. If $\beta_1 > 0$ indicates that the risk taking tendency of the enterprise will increase the variability of the enterprise's R&D investment; If $\beta_1 < 0$ indicates that the risk taking tendency of enterprises will reduce the variability of R&D investment, and the level of R&D investment will be more stable. When the regression coefficient is significant at a statistical level of at least 10%, it indicates that the impact of enterprise risk-taking propensity on the variability of R&D investment is significant, and the research results are statistically significant. If H2 is assumed to hold, then $\beta_1 < 0$.

$$R\&D\ power_{i,t}=\beta_0+\beta_1 RT_{i,t}+\beta_2 Tech_{i,t}+\beta_3 RT_{i,t}*Tech_{i,t}+\beta_4 Gov_{i,t}+\beta_5 Balance_{i,t}+\beta_6 Roa_{i,t}+\beta_7 Num_{i,t}+\beta_8 Age_{i,t}+\beta_9 Slack_{i,t}+\beta_{10} Lev_{i,t}+\beta_{11} Der_{i,t}+\beta_{12} Man_{i,t}+\sum YEAR+\sum IND+\varepsilon_{i,t} \quad (3)$$

On the basis of model (1), the moderating variables $Tech_{i,t}$, and the interaction term $RT_{i,t}$* $Tech_{i,t}$ are added to construct model (3) to verify hypothesis H3.1, which verifies the moderating effect of management's technical background on the process of enterprise risk taking propensity affecting R&D investment intensity. Observe the regression coefficients and significance of the interaction terms $RT_{i,t}$*$Tech_{i,t}$, based on the hypothesis H1, if $\beta_3 > 0$ indicates that the technical background of the management will strengthen the positive correlation between the risk taking tendency of the enterprise and the intensity of the enterprise's R&D investment; if $\beta_3 < 0$, it indicates that the technical background of the management will weaken the positive correlation between the risk taking tendency of the enterprise and the intensity of the enterprise's R&D investment. If H3.1 holds, then $\beta_3 > 0$.

$$R\&D\ variability_{i,t}=\beta_0+\beta_1 RT_{i,t}+\beta_2 Tech_{i,t}+\beta_3 RT_{i,t}*Tech_{i,t}+\beta_4 Gov_{i,t}+\beta_5 Balance_{i,t}+\beta_6 Roa_{i,t}+\beta_7 Num_{i,t}+\beta_8 Age_{i,t}+\beta_9 Slack_{i,t}+\beta_{10} Lev_{i,t}+\beta_{11} Der_{i,t}+\beta_{12} Man_{i,t}+\sum YEAR+\sum_{IND}+\varepsilon_{i,t} \quad (4)$$

On the basis of model (2), the moderating variables $Tech_{i,t}$, and the interaction terms $RT_{i,t}$*$Tech_{i,t}$ are added to construct model (4) to verify hypothesis H3.2, which verifies the moderating effect of management's technical background on the variability of R&D investment in the process of enterprise risk taking propensity. Observe the regression coefficients and significance of the interaction terms $RT_{i,t}$*$Tech_{i,t}$, and on the basis of assuming H2, if $\beta_3 > 0$ indicates that the technical background of the management will weaken the negative correlation between the risk taking tendency of the enterprise and the intensity of the enterprise's R&D investment; if $\beta_3 < 0$, it indicates that the technical background of the management will strengthen the negative correlation between the risk taking tendency of the enterprise and the variability of the enterprise's R&D investment. If H3.2 holds, then $\beta_3 < 0$.

The specific definitions of each variable are shown in Table 1.

5. Results

This study conducted full sample descriptive statistics on the selected sample data, and the results are shown in Tables 2.

The regression results can be seen from Table 3 that there is a significant positive correlation between enterprise risk taking tendency and R&D investment intensity at the 1% level (β=2.362, t=3.53), indicating that an increase in the risk taking tendency of enterprises will increase their R&D investment intensity, verifying hypothesis H1. Specifically, on the one hand, the tendency of enterprises to bear risks affects the process of balancing project benefits and risks. When the risk taking tendency of the enterprise increases, in the decision-making of a single R&D project, R&D projects with higher risks will be decided by the enterprise management. On the other hand, the tendency of enterprises to bear risks also affects the overall risk management process of the enterprise. In the overall risk control process of the enterprise, more research and development projects will be carried out. Taking into account both factors, the stronger the risk taking tendency of a company, the higher its tolerance for risk, and the more it will invest in research and development, resulting in a higher intensity of investment in research and development. Considering the impact of heteroscedasticity, this study corrected the heteroscedasticity of the model, and the regression coefficients remained unchanged after correction. The positive impact of enterprise risk taking tendency on R&D investment intensity was robust.

There is a significant negative correlation between the propensity of enterprises to take risks and the variability of R&D investment at the 5% level(β=- 0.389, t=-2.55), indicating that an increase in the risk taking tendency of enterprises will reduce the variability of R&D investment and improve the stability of R&D investment. This result validates hypothesis H2. Specifically, the tendency of

enterprises to take risks will suppress the volatility of R&D investment caused by objective factors. On the one hand, when there is an adverse change in the objective factors of the enterprise, a higher risk taking tendency will make the enterprise still have a positive attitude towards risk, risking a certain amount of excess risk, maintaining the original R&D investment or experiencing a relatively small contraction, thereby ensuring the stable investment of R&D resources and the timely output of R&D projects. On the other hand, enterprises with a high risk taking tendency will try their best to develop R&D projects that can bring profits to the enterprise. When some objective factors of the enterprise undergo favorable changes, and under the constraints of restrictive resources, enterprises

Table 1. Variable Definition

Variable type	Variable name	Variable Symbol	Variable Definition
Dependent variables	R&D investment intensity	R&D power	The ratio of enterprise R&D investment amount to average total assets multiplied by 100.
	R&D investment variability	R&D variability	The coefficient of variation of the R&D investment amount of enterprises in the past four years (including this year).
Independent variable	Enterprise risk taking tendency	RT	The standard deviation of the daily stock return rate of a company during the year.
Moderator variable	Management technical background	Tech	The proportion of managers with technical backgrounds to the total number of management in the enterprise.
Controlled variables	Property nature	Gov	Virtual variable, state-owned property=1, non-state-owned property=0.
	Equity balance	Balance	The proportion of shares held by the largest shareholder to the top ten shareholders.
	Enterprise performance	Roa	The performance of a company in the previous period, which is the ratio of its net profit before interest and tax to total assets.
	Number of management personnel	Num	The total number of management personnel, including the number of directors, supervisors, and executives.
	Age of management	Age	The average age of management.
	Available redundancy	Slack	The ratio of current assets to current liabilities.
	Debt paying ability	Lev	Asset liability ratio, which is the ratio of total liabilities to total assets.
		Der	Potential redundancy refers to the ratio of total liabilities to total market value.
	Proportion of males in management	Man	The ratio of the number of male management personnel to the total number of management personnel.
	Industry variables	Industry	Virtual variables.
	Annual variables	Year	Virtual variables.

Table 2. Full sample descriptive statistics

Variable	N	Mean	Sd	Min	Median	Max
R&D power	15715	2.860	2.386	0.009	2.408	12.576
R&D variability	15715	0.299	0.229	0.018	0.241	1.332
RT	15715	0.030	0.013	0.012	0.029	0.178
Tech	15715	0.408	0.199	0.000	0.400	0.909
Gov	15715	0.274	0.446	0.000	0.000	1.000
Balance	15715	0.555	0.185	0.121	0.544	0.990
Roa	15715	0.042	0.085	-1.648	0.044	0.786
Num	15715	15.681	3.506	8.000	15.000	35.000
Age	15715	49.774	3.451	34.000	49.818	71.000
Slack	15715	2.509	2.245	0.429	1.758	13.871
Lev	15715	0.409	0.198	0.008	0.402	3.919
Der	15715	0.279	0.197	0.002	0.234	1.004
Man	15715	0.787	0.124	0.200	0.800	1.000

With a higher risk taking tendency have limited space to increase their R&D investment. So, regardless of how the objective factors of the enterprise change, when the enterprise's risk taking tendency increases, the variability of the enterprise's R&D investment will decrease. The heteroscedasticity of the model was corrected before regression, and the results were roughly the same as before.

Table 3. Regression Results of the Relationship between Enterprise Risk Bearing Tendency and R&D Investment

Variable	R&D power	R&D variability	R&D power-corrected	R&D variability-corrected
RT	2.362***	-0.389**	2.362***	-0.389***
	(3.53)	(-2.55)	(4.46)	(-4.00)
Gov	-0.045	-0.010	-0.045	-0.010
	(-0.84)	(-0.83)	(-0.79)	(-0.96)
Balance	-0.049	-0.046*	-0.049	-0.046*
	(-0.45)	(-1.84)	(-0.43)	(-1.90)
Roa	0.340***	0.163***	0.340***	0.163***
	(3.54)	(7.49)	(2.90)	(7.38)
Num	0.011**	0.003***	0.011**	0.003***
	(2.19)	(3.11)	(2.49)	(3.25)
Age	0.005	-0.002**	0.005	-0.002***
	(1.12)	(-2.39)	(1.26)	(-2.80)
Slack	-0.082***	-0.011***	-0.082***	-0.011***
	(-10.19)	(-5.91)	(-8.52)	(-6.43)
Lev	0.108	0.194***	0.108	0.194***
	(0.85)	(6.73)	(0.82)	(6.71)
Der	-1.222***	-0.082***	-1.222***	-0.082***
	(-9.42)	(-2.79)	(-10.03)	(-2.64)
Man	-0.176	0.058**	-0.176*	0.058**
	(-1.49)	(2.15)	(-1.65)	(2.32)
_Cons	2.799***	0.522***	0.822	0.289*
	(6.12)	(5.02)	(1.56)	(1.83)
Year	Controlled	Controlled	Controlled	Controlled
Ind	Controlled	Controlled	Controlled	Controlled
R2	0.049	0.037	0.939	0.658
adj. R2	-0.302	-0.318		
F	17.839	13.262		
N	15715	15715	15715	15715

Note: ***, **, * respectively represent significant values at the 1%, 5%, and 10% levels; t-values in parentheses.

The interaction term Tech*RT is significantly positively correlated with the intensity of enterprise R&D investment at a statistical level of at least 1%(β=11.214, t=3.77), indicating that the technical background of the management can positively regulate the promoting effect of enterprise risk taking tendency on R&D investment intensity, verifying hypothesis H3.1. Specifically, the technical background of the management will divide their decision-making behavior, enhance their willingness and ability to conduct research and development, and further strengthen their preference for research and development projects. When the technical background of the management is strong, the tendency of the enterprise to bear risks increases, which will lead to more research and development investment than enterprises with weaker technical background of the management.

The interaction term Tech*RT is significantly negatively correlated with the variability of R&D investment at a statistical level of at least 10%(β=-1.163, t=-1.72). The above results indicate that the management's technical background strengthens the significant negative correlation between the enterprise's risk taking propensity and the variability of R&D investment, verifying the research hypothesis H3.2. Specifically, when objective factors undergo adverse changes, companies with

Table 4. Regression Results of the Impact of Management's Technical Background on the Relationship between Enterprise Risk Bearing Tendency and R&D Investment

Variable	R&D power	R&D variability	R&D power-corrected	R&D variability-corrected
RT	-2.469*	0.112	-2.469**	0.112
	(-1.71)	(0.34)	(-2.33)	(0.51)
Tech	-0.371***	0.034	-0.371***	0.034*
	(-3.36)	(1.37)	(-4.53)	(1.81)
Tech*RT	11.214***	-1.163*	11.214***	-1.163***
	(3.77)	(-1.72)	(5.05)	(-2.71)
Gov	-0.045	-0.010	-0.045	-0.010
	(-0.83)	(-0.83)	(-0.78)	(-0.96)
Balance	-0.042	-0.047*	-0.042	-0.047*
	(-0.38)	(-1.88)	(-0.37)	(-1.94)
Roa	0.340***	0.163***	0.340***	0.163***
	(3.55)	(7.49)	(2.90)	(7.37)
Num	0.010**	0.003***	0.010**	0.003***
	(2.13)	(3.12)	(2.43)	(3.26)
Age	0.006	-0.003**	0.006	-0.003***
	(1.24)	(-2.39)	(1.39)	(-2.80)
Slack	-0.082***	-0.011***	-0.082***	-0.011***
	(-10.19)	(-5.92)	(-8.53)	(-6.44)
Lev	0.123	0.193***	0.123	0.193***
	(0.97)	(6.68)	(0.93)	(6.65)
Der	-1.240***	-0.080***	-1.240***	-0.080***
	(-9.56)	(-2.72)	(-10.17)	(-2.58)
Man	-0.181	0.059**	-0.181*	0.059**
	(-1.53)	(2.18)	(-1.69)	(2.35)
_Cons	2.922***	0.510***	0.936*	0.277*
	(6.38)	(4.88)	(1.78)	(1.75)
Year	Controlled	Controlled	Controlled	Controlled
Ind	Controlled	Controlled	Controlled	Controlled
R2	0.050	0.037	0.939	0.658
adj. R2	-0.300	-0.318		
F	17.251	12.590		
N	15715	15715	15715	15715

Note: ***,**,*respectively represent significant values at the 1%, 5%, and 10% levels; t-values in parentheses.

lower risk taking tendencies will have more confidence in research and development projects due to the technical background of senior management, in order to better respond to potential problems caused by adverse changes in objective factors by increasing research and development investment. At this point, the intensity of enterprise R&D investment will experience significant fluctuations. On the other hand, enterprises with higher risk taking tendencies have limited room for improvement, but also higher risk resistance, which can maintain the current level of R&D investment well. However, it is difficult to find new projects that can bring significant returns to the enterprise. Therefore, the intensity of R&D investment will maintain a relatively stable state. When there is a favorable shift in objective factors, enterprises with a high risk taking tendency will maintain a relatively stable level of R&D investment due to the limitations of minimum factors or the difficulty in seeking new R&D projects. However, enterprises with a low risk taking tendency will develop more R&D projects than enterprises with a low technology background due to the strengthening of management's technical background, making R&D investment more variable. Therefore, when the management has a strong technical background, the increase in risk taking tendency will have a stronger impact on the stability of research and development investment.

After adjusting for the heteroscedasticity of the model and regressing, the results were roughly the same as before, but the negative moderation significance between the management's technical background and the variability of enterprise risk taking tendency and R&D investment was significantly improved.

In order to ensure the robustness of the above empirical results, this article considers the impact of endogeneity on the research results and analyzes the potential endogeneity issues that may exist in the model. Subsequently, this study conducted endogeneity treatment on the regression model of R&D investment variability. Select l.RT2 with one lag period and l2.RT2 with two lags periods as instrumental variables, and generate new moderating variables Tech*l.RT2 and Tech*l2.RT2 in sequence, verified the rationality of the instrumental variables and the robustness of the research results.

In addition, this study also tested the robustness of the research results through methods such as replacing explanatory variables, placebo tests, and replacing moderating variables, and the test results proved the robustness of the results.

6. Discussion and conclusions

Through a series of empirical analysis, this article draws the following conclusion: (a) An increase in the risk taking tendency of enterprises will increase the intensity of R&D investment. (b) The increase in risk taking tendency of enterprises will reduce the variability of R&D investment and improve the stability of R&D investment. (c) The technical background of the management can positively regulate the promoting effect of the enterprise's risk taking tendency on the intensity of research and development investment. (d) The technical background of the management has strengthened the significant negative correlation between the enterprise's risk taking tendency and the variability of R&D investment.

The research deficiency of this article lies in: (a) the measurement method of enterprise risk taking tendency needs to be optimized. (b) The indicators for the variability of R&D investment are relatively single. (c) There is no breakdown of the technical background of the management.

The following research can start from the following aspects: (a) Design a scale to conduct a questionnaire survey on management personnel, directly quantifying the overall risk taking tendency of enterprises, and further verifying the significant impact of enterprise risk taking tendency on the intensity and variability of R&D investment. (b) Select the degree of deviation between R&D intensity and expected R&D intensity to replace the original measurement method, and once again study and analyze the relationship between enterprise risk taking and R&D investment variability, as well as the role of management's technical background in the relationship between the two. (c)

Subdivide the technical background of the management team. From the perspectives of the board of directors, independent directors, supervisory board, executive technical background, and whether the CEO has a technical background, this study compares the impact of these factors on the relationship between enterprise risk taking tendencies and R&D investment, in order to further provide empirical evidence for optimizing the management structure of enterprises.

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