Journal of Information Economics

Homepage: https://anser.press/index.php/JIE

Internal controls and corporate technological innovation: Empirical evidence from Chinese listed companies

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ABSTRACT

As the underlying institutional design for enterprise risk management, it is important to study whether and how internal control affects enterprise technological innovation in the current context of increased economic policy uncertainty. Based on the principal-agent theory and information asymmetry theory, this paper explores the impact of internal control on corporate technological innovation using the listed company data from 2009-2019 CSMAR database, and obtains the following research conclusions: (1) the quality of internal control positively affects the corporate technological innovation. (2) The operational risk plays an intermediary role in the relationship between the internal control affecting the corporate technological innovation. (3) The degree of market competition positively moderates the impact of internal control on enterprise technological innovation. (4) Relative to non-state-owned enterprises and non-high-tech enterprises, the quality of internal control of state-owned enterprises and high-tech enterprises has a more significant impact on enterprise technological innovation. This paper enriches the consequences of the study of internal control on the one hand, and on the other hand, it provides a new perspective for improving technological innovation, and it provides certain guidance for further improving the level of corporate governance.

KEYWORDS

Internal control quality; Technological innovation; Business risk; Marketability

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ISSN 2972-3671
doi: 10.58567/jie01020005

Received 18 March 2023; Accepted 15 May 2023; Available online 1 July 2023

1. Introduction

Nowadays, the world is experiencing a great change that has not been seen in a hundred years, and the domestic and foreign environments facing China's development are undergoing profound and complicated changes, and the development of China in the "14th Five-Year Plan" period as well as in a longer period of time puts forward more urgent requirements for accelerating scientific and technological innovation. Accelerating scientific and technological innovation is necessary for promoting high-quality development and constructing a new development pattern, and smoothly starting a new journey of building a socialist modernized country (Chen, 2021). As the main body of innovation, the innovation achievements of enterprises are directly related to the survival and development of enterprises, and are the inexhaustible source and driving force for the sustainable development of enterprises. However, innovation is different from the regular production of enterprises, innovation is characterized by high uncertainty and long cycle, so it is necessary for enterprises to create an environment that dares to innovate and tolerates failure. Since the implementation of China's "Basic Standard for Enterprise Internal Control" in 2008, corporate governance is required to control risks and develop effective control measures for each node of innovative business. In this case, the strengthening of internal control can provide better support for enterprise innovation, but it may also cause the enthusiasm of enterprise innovation to weaken due to the cumbersome internal control process (Zhang et al., 2017). Therefore, the impact of internal control on enterprise technological innovation needs to be specifically analyzed from different perspectives.

Currently scholars have made unremitting exploration on this issue, and the research conclusions mainly focus on two aspects: (1) Internal control promotion theory, i.e., there is a positive relationship between internal control and enterprise R&D investment. Along with the improvement of the level of internal control, the internal agency problem of the enterprise is further solved, so the enterprise's inefficient investment is reduced (Fang and Jin, 2013). The improvement of the quality of internal control can also reduce the asymmetry of information and alleviate the financing constraints of the enterprise (Zheng et al., 2013). The internal control contains a more reasonable risk management, more standardized control activities and more scientific management, so it can improve the operational efficiency, enhance the enterprise's ability to resist risks, and thus have greater innovative performance. (2) Internal control paradox, i.e., internal control hinders enterprise input and reduces innovation performance. Internal control implies that enterprises are based on institutional constraints, and there are strict procedural norms for enterprise production and operation decisions, which is contradictory to the flexibility required for enterprise innovation (Ribstein, 2002). In addition, internal control focuses on the risk of pre-defense, focusing on the effect of executive incentives, so the motivation of enterprise innovation investment is weaker (Zhang, 2007). The strengthening of internal control means that enterprises are more cautious in the use of financial funds (Wang and Song, 2014) and innovation is uncertain, so it will also reduce the investment in innovation (Du et al., 2022).

Current research on the relationship between internal control and corporate technological innovation has not reached a consistent conclusion, the reason may be the measurement of internal control and research perspective is different, so this paper starts from the enterprise business risk, research on the impact of internal control on corporate technological innovation and the boundary mechanism, aimed at enriching the existing research to explain the relationship between the two to do further exploration.

Based on this, this paper uses data from listed companies in China from 2009-2019 to test the impact and mechanism of internal control on corporate technological innovation, with the following three main contributions: first, it adds evidence for the internal control promotion theory from the perspective of corporate technological innovation. Existing studies are controversial about the influence effect of internal control, and this paper supports the internal control promotion theory viewpoint to a certain extent. Second, it enriches the role mechanism of internal control affecting corporate technological innovation. It explores the mediating mechanism of business risk and the moderating effect of the degree of market competition, which helps to further understand how internal

control affects corporate technological innovation. Third, it provides theoretical support for state-owned enterprises and high-tech industries to strengthen the construction of internal control system. The research in this paper shows that the effect of internal control on enterprise technological innovation is more significant in state-owned enterprises and high-tech industries.

2. Literature Review and Research Hypotheses

2.1 Internal control and technological innovation in enterprises

Internal control, as defined in the Basic Standard for Internal Control, is a process implemented by the board of directors, the supervisory board, the management and all employees of an enterprise to implement control objectives. The ultimate goals of internal control are: legal compliance of operations, safety of assets, truthfulness and integrity of financial reports and related information, improvement of efficiency and effectiveness, and promotion of the realization of strategic objectives. Principal-agent theory suggests that the utility function pursued by the principal and the agent is inconsistent, with the principal pursuing the maximization of its own wealth and the agent pursuing the maximization of salary and allowances as well as personal rights and interests, which brings about a conflict of interest, and the agent may ultimately harm the interests of the principal if there is no reasonable system of control and the agent is driven by the interests of all parties. Of course, in the case of a high level of internal control, both managers and principals are proposed with corresponding institutional constraints, which can effectively prevent the misappropriation behavior of one of the parties (Zhang, 2020). Based on this analysis, it is easier to understand the investment in technological innovation, the optimization of internal control strengthens the institutional constraints of the enterprise's production and operation, which is conducive to the enterprise to make the best production and operation decisions, and innovation as the core element of the enterprise to obtain the competitiveness of the enterprise is essential for the long-term development of the enterprise, therefore, the optimization of the internal control can reduce the manager's agency problem, which in turn will make it easier to make the investment in increasing technological innovation (Xu and Feng, 2017).

Analyzed from the perspective of technological innovation, technological innovation refers to the application of innovative knowledge and new technologies, new techniques, the use of new production methods and management modes, improve product quality, develop and produce new products, provide new services to occupy the market and realize market value. However, the problem of "difficult financing" and "expensive financing" of Chinese enterprises restricts the investment in technological innovation. The optimization of internal control can improve the quality of accounting information, and high-quality accounting information can improve the enthusiasm of investors, reduce the cost of financing for enterprises, and provide financial support for technological innovation (Li and Zhang, 2019). The optimization of internal control can improve the quality of accounting information. From the perspective of information asymmetry, the improvement of internal control quality can alleviate the problem of insufficient investment in innovation caused by information asymmetry. On the one hand, high-quality internal control can improve the quality of corporate financial reporting (Liu et al., 2013), so that investors have a better perception of the profitability of the enterprise, which is conducive to reducing the risk of investor expectations, lowering the cost of equity capital of the enterprise, and providing adequate protection for technological innovation and R&D investment. On the other hand, high-quality internal control can alleviate the information asymmetry between enterprises and financial institutions, reduce the cost of banks in screening and supervising enterprises, and thus help reduce the cost of enterprise credit (Zhou et al., 2020) and improve the possibility of enterprise innovation investment.

In summary, internal control alleviates the agency problem from the level of enterprise operation, improves the quality of accounting information from the outside, alleviates the financing constraints to provide protection for

enterprise technological innovation, Therefore, we propose the hypothesis 1 of this study: All other things being equal, the quality of internal control is positively correlated with the technological innovation of the enterprise.

2.2. Mediation of operational risk

The ultimate purpose of internal control is to control risk, which contains a risk management system that can reduce the uncertainty of enterprise production and operation, and reasonably avoid qualitative and systematic risks to achieve the goal of maximizing enterprise value, and its intrinsic mechanism is that the higher the level of internal control, the more effective the enterprise can control the risk, and the better the identification of and response to internal control, and eliminate the negative impacts of risks as far as possible (Fang and Chen, 2015). Business risk is due to changes in the external economic environment and the internal operating conditions of the enterprise, resulting in the uncertainty of the future operation of the enterprise and the loss that may be caused. First, when the uncertainty of the external business environment increases, the non-production expenditure and tax expenditure of the enterprise will also increase, and the increase of the transaction cost of the enterprise will reduce the possibility of R&D investment, thus prompting the enterprise to reduce the R&D expenditure (Yu and Liang,2019). Furthermore, economic policy uncertainty will increase financial market risk and corporate risk aversion motives, which in turn will lead enterprises to adopt corresponding risk aversion activities, such as increasing cash holdings, decreasing the speed of capital restructuring and product innovation (Baker et al., 2016). Zou et al., (2020) found that when the business risk rises, its investment and liability decisions will be more conservative, which is manifested in the contraction of the balance sheet and the decline of leverage, and leverage, as an important financial indicator within the enterprise, profoundly affects the enterprise R&D investment, which affects the enterprise technological innovation.

In the face of the current world economic form of change, enterprise operation is facing greater uncertainty, and internal control as an effective system to ensure that not only can motivate managers to work hard, improve capital efficiency, pay close attention to changes in the economic outlook and then form an effective prediction mechanism. It can also alleviate the agency problem, i.e., constrain managers' risk aversion leading to underinvestment in innovation, and also constrain managers' blind investment, thus reducing the business risk of enterprises. Sun and Yang (2013) study that the more sound the enterprise's internal control, the more standardized and scientific its business processes, internal information and communication, the formation of orderly internal management for the timely recognition and measurement of accounting information provides a guarantee. And the transparency of accounting information can not only mitigate the business risk, but also help to reduce the cost of external financing of enterprises. Not only that, effective internal control can reduce the information risk, thus reducing the company's cost of equity (Ashbaugh and Collins, 2009; Wang et al., 2022).

In summary, the better the quality of internal control, on the one hand, the better the transparency of accounting information and accounting robustness, which can alleviate the agency problem and thus reduce the business risk of enterprises in order to enhance the technological innovation of enterprises; on the other hand, a high level of internal control can alleviate the asymmetry of information between the enterprise and the financial institution, which can reduce the business risk of both parties, thus reducing the cost of credit to alleviate the financing constraints, and then enhance the enterprise's technology innovation performance. Therefore, the hypothesis 2 of this study is proposed: all other things being equal, the level of internal control affects enterprise technological innovation by influencing enterprise business risk.

2.3. The moderating role of the degree of market competition

As an external governance mechanism, the degree of market competition can fully mobilize the vitality of

market competition. Arrow (2016) and other scholars suggest that a competitive market environment can bring greater incentives to enterprise R&D and help improve enterprise R&D efficiency. Some scholars from the basic principles of internal control, that the degree of competition in the external market, enterprises will face greater business risks, the ultimate goals of internal control is to reduce business risks, maximize enterprise value, so the market competition environment will inhibit the impact of internal control on corporate technological innovation (Wang et al., 2019). At present, there is no consistent conclusion on the study of the degree of market competition on internal control and technological innovation; this study, based on the information hypothesis and the escape effect, believes that there is a positive moderating effect of market competition on the relationship between internal control and technological innovation; first of all, based on the information hypothesis, it is believed that the greater the degree of competition in the market, the higher the management in order to improve the efficiency of the investment and the market share will improve the quality of information disclosure, thus alleviating the asymmetry of the information(Jiang et al., 2015). First, based on the information hypothesis, it is believed that the greater the degree of market competition, the better the management will improve the quality of information disclosure in order to improve investment efficiency and market share, thus alleviating the information asymmetry. Furthermore, when the external market is more competitive, a buyer's market is formed in the industry and profitability will be squeezed, enterprises have to increase innovation to escape from the current low-end competitive environment, so high quality internal control can react quickly to increase the possibility of escaping (Aghion and Howitt,2013).

In summary, the degree of market competition on the one hand is conducive to the full play of the role of enterprise internal control, to provide soil for enterprise technological innovation, in addition, the degree of market competition can also be forced to give full play to the advantages of internal control, increase innovation investment to enhance the efficiency of enterprise technological innovation, therefore, put forward the hypothesis of this study 3: the degree of market competition in the relationship between the internal control of the impact of enterprise technological innovation play a positive role in the regulation. Therefore, hypothesis 3 of this study is proposed: the degree of market competition plays a positive moderating role in the relationship between internal control and technological innovation.

3. Research design

3.1. Sample selection and data sources

Starting from the above analysis, this study selects the data of Chinese A-share listed companies from 2009-2019 as the initial research sample, and further deletes the sample by combining the research theme: (1) deleting the sample of companies with gearing ratio greater than 1; (2) deleting the financial category, ST category, and the companies with serious missing data, and finally obtaining a total of 15,487 observations from 2,757 companies. In terms of data sources, the financial indicators are all from the Cathay Pacific database CSMAR and the WIND database WIND, the enterprise patent data are from the China Research Data Service Platform, and the internal control data are from the Dibao Listed Company Internal Control Index.

3.2. Modeling

First, to verify the impact of internal control on corporate technological innovation, the following research model is set with reference to Wang (2019):

$$Innovation_{i,t} = \beta_0 + \beta_1 * IC_{i,t} + \beta_2 * Controls + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

In model (1), the subscript i company code, t denotes the year, and j denotes the industry in which it operates. $Innovation_{i,t}$ denotes the number of patents granted by company i in year t; $IC_{i,t}$ denotes the quality of internal

control of company i in year t; *Controls* are the control variables in the above table; γ_i represents firm fixed effects, μ_t represents time fixed effects, and ε_{it} is the error term.

Secondly, in order to verify the mechanism of internal control on technological innovation, the specific model is set up as follows using the test of mediation by Wen (2006), and Ren et al. (2023):

$$Risk_{i,t} = \alpha_0 + \alpha_1 * IC_{i,t} + \alpha_2 * Controls + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

$$Innovation_{i,t} = \gamma_0 + \gamma_1 * IC_{i,t} + \gamma_2 * Risk_{i,t} + \gamma_3 * Controls + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (3)$$

In model (2)(3), the subscript i company code, t denotes the year, and j denotes the industry in which it operates. $Risk_{i,t}$ denotes the business risk of company i in year t;

In addition, in order to verify the moderating effect of the degree of market competition on internal control and technological innovation, the interaction term $(IC_{it} * HHI_{i,t})$ is introduced to construct model (4) as follows:

$$Innovation_{i,t} = \theta_0 + \theta_1 * IC_{i,t} + \theta_2 * HHI_{i,t} + \theta_3 * IC_{i,t} * HHI_{i,t} + \theta_4 * Controls + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (4)$$

3.3. Variables Definition

(1) Technological innovation (Innovation); drawing on the research of Meng et al., (2018) measured by the quantity of innovation output and the quality of innovation output, the number of patents granted is used to measure the quantity of innovation output (Innovation1). Invention patents have a long research and development cycle and high technological content, so the number of invention patents granted is used to measure the quality of innovation output (Innovation2).

(2) Internal control quality (IC); the internal control index adopts the internal control index of listed companies in Dibao and divides it by 100 as a measurement index. The index is based on the internal control elements and objectives of Shenzhen Dibao enterprises, and then further analyzes the internal control reports of the enterprises, and finally calculates the index based on the types of audit reports and internal control deficiencies of the enterprises. The index reflects the enterprise's internal control system more objectively.

(3) Operational risk (Risk): Drawing on the research of Liao (2009), the standard deviation of the income from main business within three years is used to measure the operational risk of the enterprise.

(4) Degree of market competition (HHI): Referring to the study of Zhao et al. (2013), this paper adopts the Herfindahl Index HHI to measure the degree of market competition.

(5) Control variables: Considering that corporate technological innovation is not only affected by internal control, but also by other influencing factors, this study selects the following variables for control, specifically: company size (Size), growth (Growth), operating profit margin (Roa), length of time since the establishment of the company (Time), assets and liabilities ratio (Lev), concentration of shareholding (Concs), Ctrltype, and Cash Flow Ratio (Cf).

Table 1 Definition of variables

Variable type	variable symbol	Methods and descriptions of variable values
explained variable	Innovation1	Logarithmic number of annual patent grants to enterprises
	Innovation2	Logarithmic number of patents granted to Patent inventions
explanatory variable	IC	Index of internal control of listed companies/1000
mediating variables	Risk	Standard deviation of main operating income over three years
moderator variable	HHI	Herfindahl coefficients for industry years
control variable	Size	Logarithm of total assets
	Growth	(Income from main operations - income from main operations of

	the previous period)/Operating income of the previous period
Roa	Net profit/total assets
Time	Logarithm of establishment time
Level	Liabilities/assets
Concs	Shareholding ratio of the largest shareholder
Ctrltype	According to the database prospectus
Cf	Net cash flow from operating activities/total assets

4. Empirical research and analysis

4.1 Descriptive statistics

Table 2 shows the descriptive statistics of the variables. It shows that the mean value of internal control quality is 0.64, of which the minimum and maximum values differ greatly, indicating that the quality of internal control of Chinese listed companies varies at present. The mean value of the quantity of technological innovation (Innovation) and the quality of technological innovation (Patent) are 1.603 and 0.837 respectively, and the standard deviation is 1.552 and 1.105 respectively, which indicates that the technological innovation output of the listed companies varies greatly, so the study of the output of technological innovation through internal control has practical significance.

Table 2 Descriptive statistics

Variable	N	Mean	Sd	P50	Min	Max
HHI	15487	0.017	0.02	0.011	0.003	0.104
IC	15487	0.640	0.140	0.669	0	0.847
Yffy	15487	17.75	1.714	17.83	11.13	21.89
Innovation1	15487	0.837	1.105	0	0	4.663
Innovation2	15487	1.603	1.552	1.386	0	6.019
Risk	15487	0.206	0.163	0.163	0.014	0.882
Growth	14522	0.164	0.359	0.107	-0.489	2.122
Lev	15487	0.453	0.186	0.444	0.096	0.903
Clsc	15487	22.20	5.074	22	12	36
Size	15487	22.29	1.263	22.10	20.09	26.25
Roa	15487	0.033	0.059	0.034	-0.276	0.174
Cf	15487	0.043	0.063	0.042	-0.136	0.220
Concs	15487	0.341	0.145	0.322	0.085	0.737

4.2 Baseline regression results

Table 3 shows the benchmark regression results of internal control on enterprise technological innovation, column (1) (2) indicates the multiple regression analysis of the whole sample, after controlling other influencing factors, no matter using the quantity of technological innovation or the quality of technological innovation to measure enterprise technological innovation, the impact of internal control on enterprise technological innovation is significantly positively correlated, which verifies the hypothesis 1. Due to the fact that the patent output of many enterprises is 0, in order to avoid the bias of OLS results, it is more appropriate to use Tobit model to analyze, so we use Poisson regression to analyze, the (3) (4) columns can be seen that the coefficient of internal control is still significantly positive, which indicates that the regression method of this study is appropriate, and also verifies the

hypothesis 1 again.

Table 3 Benchmark regression results

Variable	OLS		Poisson	
	(1)	(2)	(3)	(4)
	Innovation1	Innovation2	Innovation1	Innovation2
IC	0.452***	0.307***	0.308***	0.395***
	(4.56)	(4.68)	(4.25)	(4.15)
Growth	-0.013	0.032	-0.011	0.036
	(-0.40)	(1.49)	(-0.49)	(1.28)
Clsc	-0.029***	-0.016***	-0.018***	-0.019***
	(-10.93)	(-8.85)	(-10.71)	(-8.56)
Size	0.241***	0.233***	0.142***	0.252***
	(17.07)	(22.22)	(18.03)	(25.03)
Roa	-0.008	-0.061	0.018	0.036
	(-0.03)	(-0.34)	(0.10)	(0.14)
Lev	-0.232***	-0.455***	-0.148***	-0.550***
	(-2.83)	(-8.03)	(-2.80)	(-7.84)
Cf	0.964***	0.498***	0.602***	0.568***
	(4.70)	(3.56)	(4.57)	(3.24)
Concs	-0.000	-0.003***	-0.000	-0.004***
	(-0.43)	(-4.00)	(-0.67)	(-4.66)
ctrltype	-0.149***	0.009	-0.097***	0.005
	(-4.92)	(0.41)	(-4.98)	(0.20)
Firm fixed effect	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
_cons	-3.262***	-3.909***	-2.417***	-5.336***
	(-10.94)	(-17.59)	(-14.53)	(-25.00)
N	14522	14522	14522	14522
r2_a	0.045	0.063		
Pseudo R^2			0.188	0.033

*Note: Numbers in parentheses are t-values, and ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively.*

4.3 Robustness tests

4.3.1 Replacement of core explanatory variables

The quality of internal control is measured by whether the internal control is effective and whether there are defects in internal control, so this study re-selects the measurement of internal control, selecting the effectiveness of internal control and defects in the database of Cathay Pacific to measure, the results are shown in Table 4, column (1) (2), the coefficient of the effectiveness of internal control on the number of innovation outputs and the quality of innovation outputs is 0.087, respectively, 0.141, significant at the 5% level; the coefficient of internal control deficiencies are -0.157, -0.103, significant at the 1% level proves that the greater the internal control deficiencies, the worse the performance of technological innovation outputs; from the effectiveness of internal control and internal control deficiencies again proves the impact of the quality of internal control on the enterprise's

technological innovation, to further validate hypothesis 1.

4.3.2 Measurement with replacement of explanatory variables

According to previous research by scholars, the logarithm of R&D costs has been used to re measure technological innovation (Yffy). R&D investment is the necessary prerequisite for technological innovation. The explanatory variables for the regression analysis results are replaced as shown in column (3) of Table 4. Under the control of other influencing factors, internal control has a significant positive impact on enterprise technological innovation.

4.3.3 Instrumental Variable Method

The above discussion proves the influence of internal control on enterprise technological innovation, and in turn, enterprises with high technological innovation may pay more attention to the construction of internal control system and improve the level of internal control in order to improve the output of technological innovation, so there may be a reverse causality in this study, and we draw on the research of Doyle et al. (2007) and adopt whether listed companies are audited by the Big 4 as an instrumental variable to test the relationship between internal control and technological innovation. The two-stage least squares method is used to obtain the results as shown in column (4)(5) of Table 4. In the first stage, the relationship between instrumental variables and internal control is first verified, and the coefficient of internal control is 3.049, which is significantly correlated at 1% level; in the second stage, big4 is used to replace the internal control to re-regress, and the coefficient of internal control is 0.058, which is significantly correlated at 5% level, and the coefficient of internal control is 0.058, which is significantly correlated at 5% level, and the relationship between internal control and technology innovation is also verified in the second stage. To summarize, the positive relationship of internal control on firms' technological innovation is robust.

Table 4 Robustness test

	(1) Innovation1	(2) Innovation2	(3) Yffy	(4) Big4	(5) Innovation
yx	0.087**	0.141**			
	(2.50)	(2.63)			
qx	-0.157***	-0.103***			
	(-5.05)	(-4.63)			
IC			0.391***	3.049***	0.058**
			(3.52)	(9.22)	(2.55)
Clsc	-0.026***	-0.015***	-0.036***	0.012	-0.029***
	(-9.59)	(-7.90)	(-13.74)	(0.76)	(-11.07)
Size	0.256***	0.243***	0.770***	-0.019	0.248***
	(17.39)	(22.13)	(55.66)	(-0.26)	(17.59)
Roa	0.332	0.110	1.328***	0.374	0.402
	(1.27)	(0.62)	(5.05)	(0.32)	(1.60)
Lev	-0.222***	-0.450***	-1.129***	1.513***	-0.253***
	(-2.61)	(-7.69)	(-13.15)	(3.18)	(-3.09)
Cf	0.952***	0.493***	0.500**	-3.721***	0.919***
	(4.49)	(3.41)	(2.26)	(-3.11)	(4.48)

Concs	0.001	-0.002***	-0.007***	0.001	-0.000
	(0.52)	(-3.38)	(-6.95)	(0.16)	(-0.26)
ctrltype	-0.135***	0.022	-0.290***	-0.310*	-0.151***
	(-4.28)	(0.99)	(-8.98)	(-1.74)	(-4.98)
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
_cons	-3.458***	-4.101***	1.911***	-3.035**	-3.126***
	(-9.73)	(-16.22)	(6.44)	(-2.01)	(-10.54)
N	13808	13808	14522	14522	14522
r2_a	0.044	0.063	0.267		0.044
Pseudo R^2				0.069	

*Note: Numbers in parentheses are t-values, and ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively.*

5. Further research

5.1 Analysis of pathway mechanisms

In order to verify the intermediary role played by business risk, drawing on Hao et al. (2023) and Yang et al. (2023) intermediary test three-step method to verify, the first step to verify the impact of internal control on corporate technological innovation, the previous relationship has been fully verified; the second step to test the impact of internal control on business risk, as shown in Table 5, column (1), the better the internal control of the enterprise the lower the risk of business operations ($\theta 1$ =-0.069, p<0.000); the third step will be internal control, business risk and technological innovation into a model to test the results as shown in Table 5, column (2), after controlling other influencing factors added to the operating risk. 0.000); the third step will be internal control, business risk and technological innovation into a model for testing, the results are shown in column (2) of Table 5, after controlling other influencing factors to join the business risk, the impact of internal control on technological innovation becomes 0.383, the absolute value is smaller than the coefficient of 0.452 in Table 3, so that we can get that the business risk in the path of the influence of internal control on technological innovation plays a partial mediating role, verifying hypothesis 2.

5.2 Exploration of border mechanisms

The degree of market competition is an important external condition that interferes with the effectiveness of internal control and affects the technological innovation output of enterprises. In order to verify the moderating effect of the degree of market competition, this study adopts the moderating effect to analyze and test, in order to avoid the problem of multicollinearity between the variables, this study will produce the cross-multiplier term of the degree of market competition (HHI) and the quality of internal control (IC) after decentering the two, and the result is as shown in column (4) of Table 5, and the coefficient of the cross-multiplier term is 13.931, and it is significant at the level of 5 percent. It can be seen that the degree of market competition has a positive moderating effect on the relationship between internal control and technological innovation, i.e., the greater the competition in the external market, the stronger the impact of internal control on technological innovation of enterprises.

Table 5 Robust tests

	(1)	(2)	(3)	(4)
	Risk	Innovation	Innovation	Innovation

IC	-0.069***	0.383***	0.483***	0.731***
	(-5.19)	(3.89)	(4.87)	(5.89)
Risk		-0.998***		
		(-13.67)		
HHI			11.018***	2.056
			(18.76)	(0.66)
IC*HHI				13.931**
				(2.91)
Controls	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
_cons	0.124***	-3.138***	-3.570***	-3.738***
	(4.63)	(-10.58)	(-12.06)	(-12.47)
N	14522	14522	14522	14522
r2_a	0.051	0.055	0.064	0.065
F	62.521	71.451	95.202	88.156

*Note: Numbers in parentheses are t-values, and ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively.*

5.3 Subgroup regression analysis

5.3.1 Nature of property rights

Executives of state-owned enterprises have richer political connections, so the agency problem and corruption of executives of state-owned enterprises are more obvious compared to non-state-owned enterprises, so the optimization of internal control can reduce the occurrence of such behaviors and promote technological innovation. While non-state-owned enterprises operate flexibly, facing the complex and competitive external market, the cumbersome degree of internal control may increase the difficulty of innovation approval, which may make the enterprises miss the best time to invest, thus unfavorable to their technological innovation

5.3.2 Size of the company

The U.S. experience suggests that internal controls provide more significant benefits to large firms relative to SMEs. One important reason is that large firms have relatively complex organizational structures and a relatively wide range of operations, making it easier for large firms to take advantage of the benefits of scale in terms of internal controls. In this study, firms are categorized into two groups using the median operating income, with those whose operating income is greater than the industry median being 1, and 0 otherwise. The test results, as shown in columns (3)(4) of Table 6, indicate that the quality of internal controls of large firms has a more significant impact on firms' technological innovation.

5.3.3 Grouping by degree of marketization

The degree of marketization draws on the survey analysis of Wang et al. (2018) of China's provinces, from the survey data can be seen that there is a large difference in the economic development as well as the degree of marketization between China's provinces. In areas with a high level of marketization, the government's intervention in the market is relatively less, and the market environment is fairer, in such an environment enterprises are more willing to increase innovation investment to obtain profits, and internal control has the role of controlling risks and improving efficiency, so internal control and the degree of marketization may have a mutual gain effect. Therefore,

the degree of marketization is grouped, and from column (5)(6) of Table 6, it can be seen that in the region with low degree of marketization, the positive effect of internal control on enterprise technological innovation is significant (β=0.464, p<0.000), while in the region with high degree of marketization, the effect of internal control on enterprise technological innovation is not significant; which suggests that the internal control forms a substitution effect with the poor institutional environment, the Strengthening internal control can compensate for the unfavorable effects of the institutional environment, thus promoting technological innovation output.

Table 6 Subgroup regression

	(1) state- owned	(2) non-state-owned	(3) small-scale	(4) large-scale	(5) Low	(6) High
IC	0.162**	-0.157**	0.137*	0.388***	0.464***	0.102
	(2.26)	(-2.24)	(1.81)	(3.09)	(4.98)	(0.91)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
_cons	-2.067***	0.011	-0.596**	-4.417***	-3.712***	-4.321***
	(-7.20)	(0.0001)	(-2.13)	(-12.46)	(-14.93)	(-16.01)
N	9093	5429	7433	7089	7710	6812
r2_a	0.039	0.054	0.022	0.048	0.062	0.072

*Note: Numbers in parentheses are t-values, and ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively.*

6. 6. Research findings and management insights

6.1 Conclusions of the study

This study utilizes the data of A-share listed companies from 2009 to 2019 to verify the impact of internal control on corporate technological innovation, and analyzes the impact mechanism on this basis. The results of the study show that (1) internal control alleviates the agency problem from the enterprise operation level, improves the quality of accounting information and alleviates the financing constraints from the outside to provide guarantee for enterprise technological innovation, thus promoting enterprise technological innovation. (2) The quality of internal control brings better accounting information transparency and accounting robustness, so it can alleviate the agency problem and reduce the business risk of enterprises to enhance the technological innovation of enterprises. In addition, internal control can also alleviate the information asymmetry between enterprises and financial institutions, reduce the business risk, and thus enhance the performance of technological innovation of enterprises. (3) The market competition environment negatively regulates the relationship between internal control and enterprise technological innovation. The degree of market competition reflects the uncertainty of the external environment to a certain extent, so the risk control required by internal control will prompt enterprises to reduce technological innovation investment. Further grouping yields richer conclusions, relative to non-state-owned enterprises, the higher the internal control of state-owned enterprises, the better they can address agency problems, corrupt practices and on-the-job consumption, based on which they are conducive to corporate technological innovation; relative to small and medium-sized enterprises (SMEs), large firms, due to their more complex organizational structure and shareholding institutions, are more likely to generate innovative economies of scale with high-quality internal control; and relative to regions with high degrees of marketization, the impact of internal control on technological innovation is more significant in regions with a low degree of marketization, because the degree of external marketization can make up for the shortcomings of internal control and promote

technological innovation.

6.2 Management insights

First, improve enterprise internal control laws and regulations in order to release more power for enterprise technological innovation. Innovation is an activity full of risks and opportunities, so enterprises want to enhance the output of technological innovation, not only need the national policy guidance and financial support, but also need to strengthen their own internal control system construction, as far as possible to minimize the negative impact of internal control. Along with the economic and social development, enterprises in China are facing more complex economic forms, so the construction of internal control system should also be improved and keep abreast of the times; and in areas with low marketization, on the one hand, strengthen the reform of administrative reform to optimize the environment, and on the other hand, we should also strengthen the strength of the internal system, so that a high level of internal control to reduce the negative impacts brought by the degree of marketization.

Second, continuously promote the reform of state-owned enterprises, market-oriented reform, and reduce agency costs to give full play to the positive role of internal control of state-owned enterprises in promoting technological innovation of enterprises. Further improve the modern enterprise property right system, so that the innovation performance of state-owned enterprises and non-state-owned enterprises go hand in hand for common development. State-owned enterprises in the future reform should focus on the construction of the internal control system, and then promote the technological innovation output of state-owned enterprises. Promote market-oriented reform, improve the relationship between the government and the market, and ultimately make the internal system of enterprises and the external environment to form a good interaction to form a synergy, both give full play to the positive impact of the internal control of enterprises on innovation activities, improve the innovation capacity of enterprises, but also give full play to the positive role of internal control on other aspects of the enterprise, so as to promote the development of our country's economy in a more stable and healthy way forward.

Third, the government's internal control supervision of enterprises should be "tailored" to avoid a one-size-fits-all approach. Enterprises are often risk averse, but innovation and risk often occur at the same time, so enterprises need to take risks and innovation investment in the best balance, which needs to rely on the enterprise's own strategy and development, so the government should give a certain degree of autonomy to the enterprise's internal control, for the GEM enterprises and high-tech enterprises can be appropriately relax the supervision, in order to achieve the enterprise in the appropriate internal control of enterprise The government should give a certain degree of autonomy to the internal supervision of enterprises, so that the enterprises can realize the output of technological innovation and the maximization of enterprise value under appropriate internal control. At present, the state has issued a series of regulations on internal control in various industries, but it is necessary to further analyze the nature and properties of different industries, and formulate appropriate internal control regulations and regulatory programs according to the needs of enterprises.

Funding Statement

This research received no external funding.

Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

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