

ARTICLES

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HOW STATE-OWNED SHAREHOLDERS UNDER GOVERNMENT INTERVENTION AFFECT THE RE-INNOVATION DECISION OF ENTERPRISES AFTER TECHNOLOGICAL INNOVATION FAILURE?

Como os acionistas estatais sob a intervenção do governo afetam a decisão de inovar novamente nas empresas após falha de inovação tecnológica?

¿Cómo los accionistas estatales bajo intervención gubernamental afectan la decisión de reinnovación de las empresas después del fracaso de la innovación tecnológica?

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ABSTRACT

In a mixed ownership reform context, the participation of state-owned capital in private enterprises affects re-innovation decisions after the failure of technological innovation. This article takes a sample of A-share pharmaceutical manufacturing listed companies in China to test the impact of state-owned shareholders and their shareholding ratios on the re-innovation decisions after these enterprises have experienced technological innovation failure. The research found that state-owned shareholders in these enterprises are more likely to reduce additional innovation and adopt new innovations after the experience of failing to implement technological innovation. This phenomenon is more obvious with the increased proportion of state-owned shareholders. In addition, government intervention can effectively suppress the positive impact of state-owned shareholders on new innovation in enterprises that have experienced technological innovation failure. This paper aims to provide a theoretical basis and decision-making reference for private enterprises to improve their governance structure by introducing state-owned capital shares and relevant government departments to stimulate and optimize their re-innovation decision after technological innovation failure through appropriate intervention in private enterprises' technological innovation.

Keywords: state-owned shareholders, new innovation after failure, additional innovation after failure, government intervention, regulatory effect.

RESUMO

No contexto da reforma da propriedade mista na China, a participação do capital estatal em empresas privadas afeta a decisão de inovar novamente após a empresa já ter falhado em implementar inovação tecnológica no passado. Este artigo toma as empresas listadas de fabricação farmacêutica de ações A na China como amostras de pesquisa para testar o impacto dos acionistas estatais e suas taxas de participação na decisão de uma nova inovação de empresas privadas após o fracasso da inovação tecnológica. A pesquisa descobriu que os acionistas estatais são mais propensos a reduzir a inovação adicional e adotar a nova inovação após o fracasso. Esse fenômeno será mais evidente com o aumento da proporção de acionistas estatais. Além disso, a intervenção governamental pode efetivamente suprimir o impacto positivo dos acionistas estatais sobre a nova inovação após o fracasso das empresas privadas. Este trabalho tem como objetivo fornecer base teórica e referência de tomada de decisão para que as empresas privadas melhorem sua estrutura de governança por meio da introdução de ações de capital estatais, e departamentos governamentais relevantes para estimular e otimizar sua decisão de inovar novamente após falha de inovação tecnológica por meio de intervenção adequada na inovação tecnológica das empresas privadas.

Palavras-Chave: acionistas estatais, nova inovação após fracasso, inovação incremental, intervenção governamental, efeito regulador.

RESUMEN

En el contexto de la reforma de la propiedad mixta, la participación del capital estatal en las empresas privadas afectará sus decisiones de reinnovación después del fracaso de la innovación tecnológica. Este artículo toma como muestra de investigación a las empresas de fabricación farmacéutica de acciones A que cotizan en bolsa, en China para evaluar el impacto de los accionistas estatales y su proporción de acciones en las decisiones de reinnovación después de que estas empresas hayan experimentado el fracaso de la innovación tecnológica. El estudio encontró que después del fracaso de la innovación tecnológica en las empresas privadas, es más probable que los accionistas estatales reduzcan la innovación adicional y adopten nuevas formas de innovación. A medida que aumenta la proporción de accionistas estatales, este fenómeno será más evidente. Además, la intervención gubernamental puede frenar efectivamente el impacto positivo de los accionistas estatales en la nueva innovación después del fracaso de las empresas privadas. El objetivo de este artículo es proporcionar una base teórica y una referencia para la toma de decisiones para que las empresas privadas introduzcan acciones de capital estatal para mejorar la estructura de gobernanza a través de una intervención adecuada en la innovación tecnológica de las empresas privadas, así como para que los departamentos gubernamentales pertinentes incentiven y optimicen sus decisiones de reinnovación después del fracaso de la innovación tecnológica.

Palabra Clave: accionistas estatales, nuevas innovaciones después del fracaso, innovación adicional después del fracaso, intervención gubernamental, efecto regulador.

INTRODUCTION

With the continuous growth of the Chinese economy, state-owned capital shares in private enterprises and private capital shares in state-owned enterprises form a mixed-ownership structure that has become a new direction for China's future mixed-ownership reform and development of enterprises. Private enterprises often lack sufficient internal and external resources compared to state-owned enterprises to promote their technological innovation. Therefore, enhancing the technological innovation willingness of private enterprises is more conducive to improving the overall innovation level of the country. The success or failure of technological innovation in pharmaceutical manufacturing enterprises is not only related to their own development but is also closely tied to health and safety. Especially in the face of sudden public health emergencies, private pharmaceutical enterprises gain economic benefits from technological innovation and bring huge international influence to the country. However, due to its high investment and risk, the phenomenon of technological innovation failure objectively exists in enterprises (Zhang et al., 2024), causing people to overlook the fact that technological innovation is a continuous process of innovation based on failure or success. Meanwhile, equity structure is an important means of corporate governance and greatly affects the innovation decision-making of enterprises. When enterprises continue to innovate after technological innovation failure, state-owned shareholders encourage private enterprises to choose between two different innovation methods: additional innovation and new innovation (David, 2016). Additional innovation refers to the additional investment made by enterprises based on previous failed technological innovation results. New innovation refers to investing in entirely new technological innovation.

As China is currently in a critical period of economic transformation, the interaction between market mechanisms and government intervention in the capital market makes the government adopt market mechanisms to allocate resources to a certain extent. Government intervention can disperse the risk of failure of innovation activities (Xiong et al., 2021). The influence of the government's intervention level in the market on the re-innovation after the failure of technological innovation of private enterprises can not be ignored. Therefore, how state-owned equity shareholders can objectively assist private enterprises in making re-innovation decisions in the circumstances pointed out in this study and improve the success rate of technological innovation is an important research topic in the field of innovation management.

However, there is still little research on how state-owned shareholders affect the re-innovation decision after the failure of private technological innovation, and there is also a lack of attention to the role of government intervention in this decision-making process. The existing research mainly focuses on the impact of state-owned shareholders on the economic consequences of private enterprises. The studies analyze the relationship between failure and innovation from the theoretical perspective of learning from failure, using interviews, multiple case studies, and simulation methods. In addition, the studies explore the relationship between the executive's preferences regarding risks or the institutional environment, and the failure of a new attempt to engage in technological innovation. Besides, there is no consensus in the literature. Firstly,

from the perspective of the relationship between state-owned shareholders and the economic consequences of private enterprises, some scholars believe that the existence of state-owned shareholders can alleviate financing constraints of private enterprises, promoting technological innovation activities within these firms (Li & Yu, 2015), and improving their performance (Chen, 2015; Luo & Qing, 2019; Zhao & Chen, 2022). Especially when private enterprises incur huge “sunk costs” due to previous technological innovation failure, the participation of state-owned equity shareholders can offer significant support for private enterprises to pursue innovation activities following technological innovation failure. Private enterprises can avoid abandoning some technological innovation projects due to insufficient internal cash flow (He & Gao, 2012), or leaving behind potentially valuable technological innovation projects that have failed in the past. Scholars who hold opposing views believe that the intervention of state-owned capital will bring policy burdens to private enterprises, leading to them hiring more unnecessary employees and paying higher salaries, restricting the development of technological innovation activities, and thereby reducing enterprise performance (Li & Yu, 2015). Secondly, from the theoretical perspective of learning from failure and analyzing the relationship between failure and innovation, some scholars believe that the failure of technological innovation is beneficial for the development of enterprises’ re-innovation activities (Ucbasaran et al., 2010). Scholars with differing opinions argue that the failure of technological innovation can cause psychological distress to business managers, thus hindering the development of re-innovation activities (Mandl et al., 2016). Finally, from the perspective of the relationship between the risk appetite or institutional environment of the executive team and the failure or re-innovation of enterprise technological innovation, Xiong et al. (2021) believe that the institutional environment will significantly affect the development of re-innovation activities after the failure of technological innovation in enterprises. As the risk preference of the executive team increases, the probability of technological innovation failure in enterprises will become higher (Zhang et al., 2021); enterprises often choose to pursue new, risky innovations after a previous failure while neglecting the potential benefits of failed technology projects (Ye et al., 2021).

Therefore, based on endogenous growth theory and resource dependence theory, this article uses empirical research methods to examine the relationship between state-owned shareholders and private enterprises’ re-innovation decisions after technological innovation failure, as well as the role of government intervention in the relationship between the two. The research found that state-owned shareholders are more inclined towards private enterprises carrying out new innovation after failure, and the larger the proportion of state-owned shareholders’ shareholding, the stronger the promoting effect on carrying out new innovation. Government intervention can effectively suppress the positive impact of state-owned equity shareholders on new innovation after the failure of private enterprises. The conclusion of this research article provides a theoretical basis and decision-making reference for state-owned capital to intervene in private enterprises. It aims to improve their corporate governance structure, stimulate and optimize their re-innovation decision after technological innovation failure, and help the government reasonably intervene in private enterprise technological innovation activities.

Unlike observed in prior research that explored how the presence of state-owned shareholders affects the economic outcomes of private enterprises (Li & Yu, 2015; Luo & Qing, 2019; Zhao & Chen, 2022), this study contributes by examining how state-owned shareholders affect the decision of private enterprises to engage in a new attempt to innovate after having failed to implement a technological innovation. The conclusions can expand research on the economic consequences of state-owned shareholders and private enterprises from the perspective of technological innovation failure, enriching the theoretical extension of technological innovation theory. Secondly, this article considers the internal and external factors influencing private enterprises separately (Zhang et al., 2021). When studying the relationship between state-owned equity shareholders and the re-innovation decision of private enterprises after technological innovation failure, this research considers the relationship between the government and the market and examines the impact of government intervention between the two. The conclusions can enrich the literature on re-innovation decisions of enterprises after failed technological innovation from the perspective of government intervention, and expand the scope of application of resource dependence theory. Thirdly, unlike previous methods such as interviews, multiple cases, and simulation to study technological innovation failure or re-innovation (Xiong et al., 2021; Ye et al., 2021), this article expands the existing research methods on the failure of enterprise technological innovation through empirical data testing, improving the robustness and credibility of the results.

The article is structured as follows. Section two presents a literature review and the theoretical hypothesis. Section three introduces the methods employed, including the main variables, data sources, and model building. Section four presents the analysis of empirical results, followed by Section five with the conclusions and implications of the research.

THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

The impact of state-owned shareholders on the re-innovation decision-making of private enterprises after technological innovation failure

The endogenous growth theory holds that technological innovation is the driving force behind a country's economic growth and development, as well as the decisive factor for long-term competitive advantage (Zhang et al., 2023). Previous research has demonstrated that the success or failure of technological innovation is primarily determined by whether or not the intended goals were met (David, 2016; Gu & Ma, 2020; Xiong et al., 2021). After private enterprises introduce state-owned shareholders, these shareholders will inevitably have an impact on the selection of enterprise managers, thereby affecting their technological innovation decisions and the success or failure of technological innovation (Li & Yu, 2015). According to some scholars, incorporating state-owned equity shareholders into private enterprises can enhance their governance structure and convey a positive message to external investors that the government is ready to share risks

with these enterprises. This can attract more technological innovation resources to private enterprises, making it easier for them to acquire resources such as government subsidies and bank loans, which is beneficial for private enterprises to alleviate their underinvestment situation, and promote technological innovation (Luo & Qing, 2019). Some scholars hold the view that the problem of principal-agent in state-owned shareholding is more severe compared to that of private equity. This is because the inclusion of state-owned shareholders may weaken the internal supervision of firms, worsen management misconduct, and result in weak technological innovation, scattered resources, and crowding-out effects in private enterprises (Yuan et al., 2015). Moreover, state-owned shareholders may encroach on the economic resources necessary for the development of private enterprises in order to pursue their own political goals on topics such as taxation and employment, resulting in the waste of technological innovation resources (Liang & Feng, 2010). State-owned equity shareholders have a significant impact on the technological innovation of private enterprises, whether positive or negative. Therefore, in the enterprises' continuous technological innovation activities, the re-innovation decision after the failure of technological innovation will also be influenced by state-owned shareholders. If an enterprise attempts to innovate but fails, the state-owned shareholders may suffer the consequences of that failure. In order to save the project and achieve their own political goals, these shareholders may use state-owned capital to reduce the cost of intervention for private enterprises. This can lead private enterprises to diversify and expand blindly, ultimately becoming tools for the government's political performance objectives (Lian et al., 2011). Furthermore, failed technological innovation projects cause private enterprises to overlook their potential value and blindly choose new innovations with higher risk coefficients. Private enterprises will maintain connections with state-owned shareholders while catering to their political goals, leading them to lean toward innovative ways of maximizing political performance rather than maximizing profits. This article suggests certain assumptions based on the information provided:

H1: State-owned shareholders are more likely to reduce the additional innovation and adopt the new innovation after the failure of the private enterprises' attempt to implement a technological innovation.

H2: The higher the percentage of state-owned shareholders, the greater their influence in reducing the additional innovation and promoting the adoption of new innovation by private enterprises after technological innovation failure.

The regulatory effect of government intervention

Based on resource dependence theory, government intervention can influence corporate innovation through direct or indirect resource support (Xiong et al., 2021). During China's market-oriented reform, government intervention significantly correlates with enterprise innovation and

often plays a decisive role in the flow and allocation of resources. The government influences enterprises' strategic decisions through various intervention methods such as finance, economy, and trade. This, in turn, affects the technological innovation activities of these enterprises (Castellacci & Lie, 2015). The literature presents two opposite views. Some scholars point out that the government intervenes in enterprise technological innovation through policy tools such as tax incentives and government subsidies, which alleviate the financial pressure of enterprise technological innovation to a certain extent, reduce the managers' risk perception toward technological innovation, improve the enthusiasm of enterprise research and development, provide sufficient resource support for technological innovation, and promote enterprise innovation through knowledge sharing (Salehi & Alanbari, 2023). Also, government interventions may improve innovation results and increase innovation success rate (Jenson et al., 2016) while helping enterprises reduce the exit of digital economy innovators from the perspective of digital economy and environmental protection (Zhao & Chen, 2022) and promote green technology innovation in private enterprises (Bu et al., 2023). Opposing scholars argue that government subsidies may not promote technological innovation in enterprises but rather substitute their own R&D expenditure. In situations where the moderating system is imperfect, managers may exploit information asymmetry with the government or engage in rent-seeking activities with government officials to improperly obtain subsidies. This can lead to the diversion of government subsidies for other purposes, ultimately resulting in a decrease in the enterprises' own necessary investment in technological innovation (Catozzella & Vivarelli, 2016). In addition, government officials tend to invest more subsidies in projects with higher success rates and short-term returns, considering their own achievements and promotion. Excessive government intervention can lead managers to prioritize obtaining short-term benefits for projects, which can hinder or even damage the enterprise's own technological innovation. This can have a negative impact on the resource supply and smooth implementation of enterprise technological innovation activities. Therefore, a balance between government intervention and enterprise innovation autonomy is required to promote sustainable technological development (Ma et al., 2010). Otherwise, a situation of promotion followed by inhibition may occur (Zhong & Chen, 2023). This indicates that government intervention plays a crucial role in the technological innovation activities of private enterprises. Hence, when enterprises engage in re-innovation activities, government intervention can influence the relationship between state-owned shareholders and private enterprises. Good and moderate government intervention will promote enterprise technological innovation, help private enterprises reduce blindness, and choose reasonable re-innovation after the failure of technological innovation.

H3: Government intervention plays a negative role in moderating the relationship between the state-owned shareholders and the new innovation of enterprises after the failure of technological innovation

H4: Government intervention plays a positive role in moderating the relationship between state-owned shareholders and the additional innovation of enterprises after the failure of technological innovation

RESEARCH METHODS

Data sources

This article focused on A-share pharmaceutical manufacturing listed enterprises in China from 2011 to 2022. The data has been processed by excluding enterprises that were not listed in the entire research period, have missing data, or have been monitored for non-drug adverse reactions.

Firstly, the research used the 2012 revised version of China's Industry Classification Guidelines for Listed Enterprises, as well as those that have been processed by ST, PT, and * ST. Based on the enterprise's official website and annual reports, 398 production enterprises associated with each listed enterprise were identified and searched through the National Population and Health Science Data Sharing Platform and the Adverse Drug Reaction Database using the name of the manufacturer and drug. Technological innovation is judged based on whether it has met its expected goals. When patients experience adverse reactions due to the correct use of qualified drugs that have been strictly reviewed by relevant departments such as the national or provincial drug regulatory bureaus, the expected goal of using drugs to alleviate or eliminate symptoms has not been achieved (David, 2016; Ye et al., 2021). Therefore, when a listed enterprise experiences adverse drug reaction events in its affiliated firms within the research period, it is recognized as having gone through a technology innovation failure. Thus, the study identified a total of 32 enterprises.

Secondly, the information on state-owned participating shareholders was collected manually from the annual reports of listed enterprises.

Thirdly, the data on government intervention was obtained from the "China Provincial Marketization Index Report" published by Wang Xiaolu and Fan Gang in 2021. The sample data of the "Government Market Relationship" index is matched based on the registered location of listed enterprises.

Finally, aside from manually organizing data, all other data is sourced from CSMAR and WIND databases. Through the above sample screening, a total of 352 valid research samples were obtained.

Definition of main variables

Dependent variable: additional innovation (*ADDITIONAL*), and new innovation after the failure of technological innovation (*NEW*). Drawing on the approach of David (2016) and Ye et al. (2021),

the natural logarithm of the capitalized R&D investment of the failed enterprise in year $t+1$ is used to measure this additional innovation (*ADDITIONAL*). The natural logarithm of the expensed R&D investment of a failed enterprise in the $t+1$ year measures the new innovation after the failure (*NEW*). The additional innovation and new innovation are two different ways of innovation after the failure of enterprise technological innovation.

Independent variable: state-owned shareholder (*SOH1*) and state-owned shareholders ratio (*SOH2*). state-owned shareholders are non-financial shareholders such as government departments like the Ministry of Finance and the State-owned Assets Supervision and Administration Commission of the State Council (*SASAC*). The term “legal persons” refers to state-owned enterprises and four major asset management enterprises, which include wholly-owned subsidiaries. “Financial” shareholders mainly include social security funds, securities investment funds, insurance investment accounts, trust accounts, and bank fund accounts. If state-owned shareholders are among the top 10 shareholders of listed enterprises $SOH1 = 1$, otherwise, $SOH1 = 0$. In addition, the proportion of state-owned participating shareholders among the top 10 shareholders of listed enterprises is summed as a measure of the proportion of state-owned participating shareholders in private listed enterprises. If there is no state-owned shareholder among the top ten shareholders, then $SOH2 = 0$.

Moderating variable: Government intervention (*GOVER*). Given China’s unique national conditions, during China’s market-oriented reform, local governments have gained many resources, leading to a government-controlled allocation of resources and infrastructure through planning. In order to obtain sufficient resources for innovation, enterprises must maintain a good relationship with the government to reduce innovation risks and ensure smooth implementation. However, excessive government intervention may cause enterprise managers to prefer short-term profitable projects and reduce the government’s support for exploratory innovation activities. The “relationship between the government and the market” index involves several secondary indicators that significantly impact the allocation of economic resources. These indicators include the extent of government intervention in enterprises, the proportion of economic resources allocated by the market, the reduction of enterprises’ extra tax burden, and the reduction of government size. These factors can provide a better understanding of the role of the government in resource allocation, the impact of government expansion on normal market activities, and the level of government intervention in enterprises. This article employs the “government-market” index to measure government intervention (*GOVER*).

Control variables: Based on the research of David (2016), Xiong et al. (2021), Gu and Ma (2020), Luo and Qing (2019), and Ye et al. (2021), this article also controls for variables such as enterprise size (*SIZE*), i.e., the natural logarithm of year-end total assets, the independent directors ratio (*DLDS*), enterprise growth (*GROWTH*), or the growth rate of main operating income, return on assets (*ROE*), or the ratio of net profit to average total assets, level of technological resources (*TECH*), or the ratio of enterprise research and development expenses to main operating income, failure of technological innovation (*INNOVFAIL*), i.e., a dummy variable where 1 indicates adverse drug reactions, and 0 indicates no adverse drug reactions, and year (*YEAR*), i.e., a dummy variable indicating whether the enterprise was listed in the research 2011-2021.

Model construction

This article uses data from the shareholding ratio of state-owned participating shareholders and state-owned participating shareholders in the t -th period. It also considers the additional innovation and new innovation in the $t+1$ period after the failure of enterprise technological innovation for regression analysis. This treatment follows the research of scholars such as Ye et al. (2021) and the perspective of managers' decision-making. Based on this rationale, when an enterprise experiences a technological innovation failure in year t , the state-owned shareholders will influence the enterprises' decision to engage again in innovation according to their own interests. Therefore, to mitigate the impact of endogeneity issues on empirical results, new and additional innovations that follow the failure of enterprise technological innovation are delayed in one-phase processing. The regression model correlating the state-owned shareholders ratio to new and additional innovation following failed technological innovation is:

$$\begin{aligned} & \text{ADDITIONAL}_{(i, t+1)} \\ &= \alpha + \beta_1 \text{SOH1}_{(i, t)} + \beta_2 \text{SIZE}_{(i, t)} + \beta_3 \text{DLDS}_{(i, t)} + \beta_4 \text{GROWTH}_{(i, t)} + \\ & \beta_5 \text{ROE}_{(i, t)} + \beta_6 \text{TECH}_{(i, t)} + \beta_7 \text{INNOVFAIL}_{(i, t)} + \mu_{(i, t)} \quad (1) \end{aligned}$$

$$\begin{aligned} & \text{NEW}_{(i, t+1)} = \alpha + \beta_1 \text{SOH1}_{(i, t)} + \beta_2 \text{SIZE}_{(i, t)} + \beta_3 \text{DLDS}_{(i, t)} + \beta_4 \text{GROWTH}_{(i, t)} \\ & + \beta_5 \text{ROE}_{(i, t)} + \beta_6 \text{TECH}_{(i, t)} + \beta_7 \text{INNOVFAIL}_{(i, t)} + \mu_{(i, t)} \quad (2) \end{aligned}$$

$$\begin{aligned} & \text{ADDITIONAL}_{(i, t+1)} \\ &= \alpha + \beta_1 \text{SOH2}_{(i, t)} + \beta_2 \text{SIZE}_{(i, t)} + \beta_3 \text{DLDS}_{(i, t)} + \beta_4 \text{GROWTH}_{(i, t)} + \\ & \beta_5 \text{ROE}_{(i, t)} + \beta_6 \text{TECH}_{(i, t)} + \beta_7 \text{INNOVFAIL}_{(i, t)} + \mu_{(i, t)} \quad (3) \end{aligned}$$

$$\begin{aligned} & \text{NEW}_{(i, t+1)} = \alpha + \beta_1 \text{SOH2}_{(i, t)} + \beta_2 \text{SIZE}_{(i, t)} + \beta_3 \text{DLDS}_{(i, t)} + \beta_4 \text{GROWTH}_{(i, t)} \\ & + \beta_5 \text{ROE}_{(i, t)} + \beta_6 \text{TECH}_{(i, t)} + \beta_7 \text{INNOVFAIL}_{(i, t)} + \mu_{(i, t)} \quad (4) \end{aligned}$$

This article examines the impact of government intervention as a moderating variable on the original model:

$$\begin{aligned}
 & ADDITIONAL_{(i, t+1)} \\
 &= \alpha + \beta_1 SOH1_{(i, t)} + \beta_2 GOVER_{(i, t)} + \beta_3 SOH1 * GOVER_{(i, t)} \\
 &+ \beta_4 SIZE_{(i, t)} + \beta_5 DLDS_{(i, t)} \\
 &+ \beta_6 GROWTH_{(i, t)} + \beta_7 ROE_{(i, t)} + \beta_8 TECH_{(i, t)} + \beta_9 INNOVFAIL_{(i, t)} + \mu_{(i, t)} \quad (5)
 \end{aligned}$$

$$\begin{aligned}
 & NEW_{(i, t+1)} \\
 &= \alpha + \beta_1 SOH1_{(i, t)} + \beta_2 GOVER_{(i, t)} + \beta_3 SOH1 * GOVER_{(i, t)} \\
 &+ \beta_4 SIZE_{(i, t)} + \beta_5 DLDS_{(i, t)} \\
 &+ \beta_6 GROWTH_{(i, t)} + \beta_7 ROE_{(i, t)} + \beta_8 TECH_{(i, t)} + \beta_9 INNOVFAIL_{(i, t)} + \mu_{(i, t)} \quad (6)
 \end{aligned}$$

$$\begin{aligned}
 & ADDITIONAL_{(i, t+1)} \\
 &= \alpha + \beta_1 SOH2_{(i, t)} + \beta_2 GOVER_{(i, t)} + \beta_3 SOH2 * GOVER_{(i, t)} \\
 &+ \beta_4 SIZE_{(i, t)} + \beta_5 DLDS_{(i, t)} \\
 &+ \beta_6 GROWTH_{(i, t)} + \beta_7 ROE_{(i, t)} + \beta_8 TECH_{(i, t)} + \beta_9 INNOVFAIL_{(i, t)} + \mu_{(i, t)} \quad (7)
 \end{aligned}$$

$$\begin{aligned}
 & NEW_{(i, t+1)} \\
 &= \alpha + \beta_1 SOH2_{(i, t)} + \beta_2 GOVER_{(i, t)} + \beta_3 SOH2 * GOVER_{(i, t)} \\
 &+ \beta_4 SIZE_{(i, t)} + \beta_5 DLDS_{(i, t)} \\
 &+ \beta_6 GROWTH_{(i, t)} + \beta_7 ROE_{(i, t)} + \beta_8 TECH_{(i, t)} + \beta_9 INNOVFAIL_{(i, t)} + \mu_{(i, t)} \quad (8)
 \end{aligned}$$

Where, $ADDITIONAL_{(i,t+1)}$ and $NEW_{(i,t+1)}$ are the additional innovation and the new innovation after the technological innovation failure of the i th sample enterprise in period $t+1$, respectively. $SOH1_{(i,t)}$, $SOH2_{(i,t)}$ represent the shareholding ratio of state-owned shareholders and state-owned shareholders in the i -th sample enterprise period t . $GOVER1_{(i,t)}$, $SOH1*GOVER_{(i,t)}$, $SOH2*GOVER_{(i,t)}$, represent the level of government intervention and the moderating effect of government intervention in the i -th sample enterprise during the t -period, respectively. $SIZE_{(i,t)}$, $DLDS_{(i,t)}$, $GROWTH_{(i,t)}$, $ROE_{(i,t)}$, $TECH_{(i,t)}$, and $INNOVFAIL_{(i,t)}$, represent the enterprise size, the proportion of independent directors, enterprise growth, enterprise return on assets, enterprise technical resource level and the failure of enterprise technological innovation in period t of the i -th sample enterprise. To reduce multicollinearity, the interaction terms were centralized during regression. STATA 17 software was used for statistical analysis.

REGRESSION ANALYSIS RESULTS

The impact of state-owned equity shareholders on the re-innovation decision-making of enterprises after technological innovation failure

From the benchmark regression model in columns 1 to 4 of Table 1, after the failure of enterprise technological innovation, there is no significant correlation between the shareholding ratio of state-owned shareholders and additional innovation. After the failure of technological innovations, the shareholding ratio of state-owned shareholders and number of state-owned shareholders has a significant positive correlation with new innovation at the 1% and 5% levels, respectively. As part of the enterprise's R&D investment, additional and new innovation investments add up to the total innovation investment. Therefore, when an enterprise's total annual investment in R&D remains the same, new investment in innovation after a failure in implementing technological innovation will increase due to the participation of state-owned shareholders. This will result in a decrease in the investment made in additional innovation, confirming hypothesis H1. In addition, the higher the percentage of shares held by state-owned shareholders, the more they will promote new innovation after a technological innovation failure, confirming hypothesis H2.

The benchmark regression model has controlled for relevant variables, but there could still be endogeneity issues caused by missing variables. This may result in errors in the results. To address this concern, the processing method of Zhao et al. (2023) was adopted, using independent variable lagged data of one period as the instrumental variable and the 2SLS model for testing. (Due to length restrictions, only the second-stage regression results of the 2SLS model will be published). Based on the data presented in Table 1, it appears that among the examined companies that failed when trying to implement a technological innovation, there is no significant correlation between the ratio of state-owned shareholders and the level of additional innovation when these companies tried to innovate again. However, the new innovation is significantly positively correlated with the ratio of state-owned shareholding ratio and the number of state-

owned shareholders at the 1% level. After addressing potential endogeneity issues, the research findings align with the benchmark regression results.

Table 1. Benchmark Regression and Endogeneity Test

	Benchmark regression model				Endogeneity test(2SLS regression model)			
	ADDITIONAL	ADDITIONAL	NEW	NEW	ADDITIONAL	ADDITIONAL	NEW	NEW
SOH1	-1.186		0.238**		-0.976		0.315***	
	(1.295)		(0.092)		(1.482)		(0.12)	
SOH2		-6.283		1.008***		-7.762		1.23***
		(4.387)		(0.31)		(4.158)		(0.355)
SIZE	1.691***	1.984***	1.005***	0.96***	1.804***	2.078***	0.962***	0.932***
	(0.626)	(0.664)	(0.045)	(0.047)	(0.578)	(0.574)	(0.037)	(0.039)
DLDS	13.924	16.705	-2.482***	-2.865***	12.45	17.328*	-2.285**	-2.909***
	(11.707)	(11.936)	(0.834)	(0.844)	(9.578)	(9.577)	(1.023)	(0.979)
GROWTH	1.544	1.315	0.095	0.13	1.46	1.27	.156	0.171
	(2.568)	(2.565)	(0.183)	(0.181)	(2.745)	(2.845)	(.198)	(0.171)
ROE	-7.228	-9.171	2.105***	2.398***	-8.007	-9.891	2.413***	2.59***
	(8.090)	(8.221)	(0.576)	(0.582)	(7.609)	(7.83)	(.637)	(0.675)
TECH	68.307***	62.554***	14.975***	15.882***	69.359***	60.192***	14.101***	15.666***
	(23.046)	(23.362)	(1.642)	(1.653)	(20.311)	(21.453)	(1.996)	(2.19)
INNOVAFAIL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	-33.892	-40.516***	-4.094***	-3.064***	-35.8***	-42.661***	-3.345***	-2.51***
	(13.393)	(14.299)	(0.954)	(1.011)	(13.062)	(13.022)	(0.826)	(0.87)
R-squared	0.103	0.109	0.792	0.796	0.097	0.104	0.779	0.792

Note: *, **, and *** denote the significance level of 10%, 5% and 1% respectively, and the standard deviation is indicated in parentheses, the same as below.

Robustness test

(1) Change the estimation method. The Feasibility of the Generalized Least Squares (FGLS) method was retested. By comparing the research conclusions in Tables 1 and 2, it can be concluded that the robustness test using the FGLS regression model is consistent with the basic panel regression conclusions.

(2) Add control variables. Referring to the research methods of Ye et al. (2021), new control variables such as the integration of the board chairperson and general manager (*MANAGER*) and the degree of separation between the two powers (*POWER*) were added. According to the research conclusions in Table 3, it can be concluded that the addition of multiple control variables for robustness testing yielded results that are consistent with the basic panel regression conclusion.

Through the above different methods, robustness tests were conducted. Comparing the results in Tables 2 and 3, they were consistent with the original conclusion, indicating robustness.

Table 2. FGLS Regression Results

	ADDITIONAL	ADDITIONAL	NEW	NEW
SOH1	-0.958		0.157***	
	(1.191)		(0.086)	
SOH2		-6.348		1.055***
		(4.221)		(0.301)
SIZE	1.803***	2.013***	0.975***	0.94***
	(0.576)	(0.597)	(0.042)	(0.043)
DLDS	12.434	16.275	-2.139***	-2.779***
	(11.185)	(11.521)	(0.811)	(0.821)
GROWTH	1.461	1.321	0.142	0.165
	(2.475)	(2.467)	(0.18)	(0.176)
ROE	-7.994	-9.412	2.293***	2.531***
	(7.731)	(7.778)	(0.561)	(0.554)
TECH	69.347***	61.737***	14.212***	15.475***
	(21.895)	(22.271)	(1.588)	(1.586)
INNOVAFAIL	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
_cons	-35.773***	-41.13***	-3.593***	-2.699***
	(12.675)	(13.292)	(0.919)	(0.979)
Chi-squared	20.545	22.326	691.004	731.711

Table 3. Regression Results of Added Control Variables

	ADDITIONAL	ADDITIONAL	NEW	NEW
SOH1	-0.955		0.216**	
	(1.304)		(0.089)	
SOH2		-6.120		0.945***
		(4.386)		(0.296)
SIZE	1.769***	2.057***	0.976***	0.934***
	(0.633)	(0.669)	(0.043)	(0.045)
DLDS	7.527	10.229	-1.768**	-2.068**
	(12.462)	(12.602)	(0.846)	(0.850)
GROWTH	1.964	1.752	0.043	0.072
	(2.580)	(2.576)	(0.175)	(0.174)
ROE	-7.793	-9.881	1.955***	2.255***
	(8.162)	(8.300)	(0.554)	(0.559)
TECH	54.528**	48.825*	17.989***	18.893***
	(25.209)	(25.400)	(1.712)	(1.712)
MANAGER	2.195	2.227	-0.412***	-0.425***
	(1.510)	(1.498)	(0.103)	(0.101)
POWER	2.909	3.727	1.388**	1.233**
	(8.627)	(8.582)	(0.586)	(0.579)
INNOVAFAIL	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
_cons	-33.538**	-39.938***	-3.670***	-2.735***
	(13.564)	(14.412)	(0.921)	(0.972)
R-squared	0.115	0.122	0.813	0.817

The regulatory effect of government intervention

In the benchmark regression mentioned earlier, the shareholding ratio of state-owned shareholders and state-owned shareholders did not have a significant impact on the additional innovation. Hence, as observed in Table 4, although the multiplier term between government intervention and the shareholding ratio of state-owned shareholders has a significant impact on additional innovation, it can not be considered that government intervention has a moderating effect on the shareholding ratio of state-owned shareholders and additional innovation, which does not confirm the hypothesis H4. The benchmark regression results indicate a significant positive correlation (at 5% and 1% level) between state-owned shareholders, the state-owned shareholders

ratio, and the new innovation. Moreover, Table 4 shows that the crossover term between state-owned equity shareholders and government intervention ($SOH1 * GOVER$) is significantly negatively correlated with the new innovation at a 5% level, confirming hypothesis H3. After the company's failure when trying to implement technological innovation, it has been observed that government intervention has a significant negative moderating effect between state-owned shareholders and new innovation when the company decides to innovate again.

Table 4. The Regulatory Effect of Government Intervention

	ADDITIONAL	ADDITIONAL	NEW	NEW
SOH1	15.213**		1.046**	
	(6.247)		(0.422)	
GOVER	-1.961***	-2.724***	0.332***	0.241***
	(0.645)	(0.532)	(0.044)	(0.036)
SOH1*GOVER	-2.22**		-0.12**	
	(0.862)		(0.058)	
SOH2		48.293*		-1.472
		(25.362)		(1.73)
SOH2*GOVER		-6.228*		0.249
		(3.299)		(0.225)
SIZE	2.357***	1.986***	0.981***	0.957***
	(0.559)	(0.591)	(0.038)	(0.04)
DLDS	7.647	8.333	-2.05***	-2.121***
	(10.298)	(10.725)	(0.696)	(0.732)
GROWTH	4.006*	4.321*	-0.122	-0.107
	(2.28)	(2.316)	(0.154)	(0.158)
ROE	0.996	3.239	1.292***	1.417***
	(7.216)	(7.505)	(0.488)	(0.512)
TECH	68.336***	66.313***	14.569***	15.322***
	(20.241)	(21.043)	(1.368)	(1.436)
INNOVAFAIL	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
_cons	-32.872**	-20.333	-5.983***	-4.797***
	(12.932)	(13.166)	(0.874)	(0.898)
R-squared	0.318	0.306	0.858	0.852

DISCUSSION

The results of the empirical analysis confirmed hypotheses H1 and H2. These research conclusions represent an advance in the literature. Firstly, While [Luo and Qing \(2019\)](#) and [Li and Yu \(2015\)](#) both support the idea that state-owned shareholders can promote enterprise innovation, their research overlooks that the essence of corporate technological innovation is a process of continuous innovation based on failure or success ([Ye et al., 2021](#)). In the process of technological innovation, enterprises may encounter failure; they can either choose to invest in additional innovation for the projects that fail or invest in entirely new innovation projects ([David, 2016](#)). This study examines enterprise technological innovation, exploring the decision of re-innovation in the face of failure and the impact of state-owned shareholders on the process. It is obvious that state-owned shareholders are more likely to reduce additional innovation and adopt new innovations. The higher the percentage of state-owned shareholders, the greater their influence in reducing the additional innovation and promoting the adoption of new innovation. The research conclusions can be more comprehensive and in-depth.

Secondly, the perspective of this study is not limited to the view of the executive team or institutional environment regarding the failure or re-innovation of enterprise technology innovation, as [Gu and Ma \(2020\)](#), [Ye et al. \(2021\)](#), [Xiong et al. \(2021\)](#), [Zhang et al. \(2021\)](#) and others did. Thirdly, [Zhang et al. \(2021\)](#) research used interviews and case studies to examine corporate innovation failure from the perspective of learning from failure. Instead, this article's empirical research methods were used to go beyond these authors' methodological choices and produce more credible conclusions. The conclusion of H1 and H2 may be due to state-owned shareholders' unique identity attributes and ability to provide government resources, facilitate bank loan policies, credit, information, and other forms of support for private enterprises to carry out technological innovation. Enterprises' prejudice against the failure of technological innovation and their belief in having sufficient technological resources can lead to a desire to obtain corresponding technological innovation output through new technological innovation. However, this can lead to the waste of private enterprises' resources as they try to recover from wrong decisions made in past experiences regarding technological innovation. In some cases, state-owned shareholders and private enterprise managers may turn private enterprises into political tools to achieve their own goals and cater to the political interests of state-owned shareholders. This can happen when previous technological innovation projects fail, and both parties seek to maintain their relationship and political future. As a result, private enterprises may ignore the potential value of failed projects and blindly pursue new innovations with a higher risk coefficient. They hope to gain new technologies or products to make up for the previous failure caused by state-owned shareholders, fight back against external doubts, and save their political future.

In addition, According to the results of the empirical analysis in this article, it can be seen that assumption H3 is valid. According to [Bu et al. \(2023\)](#) and [Yuan et al. \(2015\)](#), government intervention promotes corporate innovation. However, when studying the relationship between

state-owned shareholders and corporate technological innovation, researchers overlooked the issue of re-innovation decision-making after technological innovation failure. They did not consider government intervention as a moderating variable to examine the role of government intervention in the relationship between the two. Therefore, the research conclusion of this article represented an advance from previous scholars' conclusions. The conclusion of H3 is that state-owned shareholders are compelling private enterprises to pursue new innovation blindly after the failure of technological innovation with a higher risk coefficient. This is done to protect their political interests. Effective government intervention can help state-owned shareholders objectively evaluate the outcomes of previous technological innovation failures. This can prevent them from ignoring the potential value of failed technological innovation projects for their own political interests and discourage blind development of new innovation after a failure of technological innovation with a higher risk coefficient.

CONCLUSION

This article takes Chinese A-share pharmaceutical manufacturing listed companies from 2011 to 2022 as the research sample to examine the impact of state-owned shareholders and their shareholding ratios on the two different re-innovation decisions of private enterprises after technological innovation failure: additional innovation and new innovation. Research suggests that the presence of state-owned shareholders is more likely to reduce additional innovation and adopt new innovation after the failure of technological innovation of private enterprises. The higher the percentage of state-owned shareholders, the greater their influence in reducing the additional innovation and promoting the adoption of new innovation by private enterprises after failure. Meanwhile, government intervention has a significant negative moderating effect between state-owned shareholders and the new innovation of private enterprises after failure, and when the government intervenes more, the state-owned shareholders have less of an impact on promoting new innovation after failure. This article theoretically enriches the research on technological innovation in endogenous growth theory and complements the research on government intervention in resource dependence theory. In practice, this article aims to provide a decision-making reference for private enterprises to improve their governance structure by introducing state-owned capital shares and relevant government departments to stimulate and optimize their re-innovation decision after technological innovation failure through appropriate intervention in private enterprises' technological innovation.

Based on the above conclusions, the following management implications can be drawn:

State-owned shareholders should treat the problem of technological innovation failure objectively from the perspective of the long-term development of the enterprise and should not motivate the enterprise to blindly choose re-innovation for the sake of personal or political self-interest. The findings of the study show that the presence of state-owned shareholders will lead private enterprises to choose to reduce additional innovation and increase new

innovation after technological innovation failure. However, the risk difference between new innovation and additional innovation is huge, and the enterprises have already incurred huge sunk costs due to previous technological innovation failures. If the state-owned shareholders further ignore the potential value of the enterprise's failed technological innovation projects and urge the enterprise to blindly carry out the new innovation, it will increase the waste of the enterprise's limited technological innovation resources, and it will also undermine the enterprise's confidence in continuous technological innovation. Therefore, state-owned shareholders should objectively treat the problem of technological innovation failure and the long-term development of enterprises to help private enterprises calmly summarize the experience of failure and assist private enterprise managers in making reasonable technological innovations after the failure of the re-innovation decision. These shareholders should not be proud of their "state-owned" status, seek personal or political interests, or use private enterprises as a political tool. These behaviors generate expectations of increased investment in new innovation after the failure of technological innovation and investment in access to new technologies or products to meet the demands of state-owned shareholders (who pressure the private sector to innovate blindly, potentially harming the enterprises). This results in ignoring the potential value of failed technological innovation projects for companies and causes a waste of resources.

The relevant government departments should intervene in the blind implementation of new innovations by private enterprises due to the personal or political interests of state-owned shareholders. The research conclusion indicates that the presence of state-owned shareholders can lead to private enterprises choosing to reduce additional innovation and increase new innovation after the failure of technological innovation. However, government intervention can significantly weaken the influence of state-owned shareholders on new innovation in private enterprises after the failure of technological innovation. Therefore, real-time intervention by relevant government departments can encourage state-owned shareholders to treat themselves more rationally as a special "bridge" between the government and private enterprises, leading them to objectively assist private enterprises in making re-innovation decisions after technological innovation failure from the perspective of the enterprise's long-term development. The intervention may prevent state-owned shareholders from treating private enterprises as their own political tools for personal or political interests, ignoring the potential value of failed technological innovation projects, and leading to the blind implementation of new innovation after technological innovation failure. This approach reduces waste of technological innovation resources.

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CONFLICTS OF INTEREST

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AUTHORS' CONTRIBUTION

Zhang Yang: Conceptualization; Methodology; Writing – original draft; Writing – proofreading
Zhou Wentao: Investigation; Resources; Software; Visualization, and editing.
Jiang Bingwei: Data curation; Formal analysis; Methodology; Supervision; Validation, and editing.