

Innovate Digitally via State Involvement: The Impact of State Capital Participation on Private Corporate Digital Technology Innovation

Ke Wang

Taizhou Vocational & Technical College

Xian Chen

1327901086@qq.com

Xinjiang University of Finance and Economics

Feifei Han

Wenzhou Business College

Longlong Xia

Shanghai University of Finance and Economics

Article

Keywords: State-owned Capital Participation, Private Enterprises, Digital Technology Innovation, Supply Chain Stability

Posted Date: January 7th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-7886573/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

The injection of state-owned capital is expected to provide enterprises with richer innovation resources and strategic support, potentially offering private firms a solution to the challenges of digital technology innovation. Against this backdrop, this study takes Chinese A-share listed private enterprises from 2013 to 2023 as the research sample. It examines the introduction of state-owned capital into private firms as the entry point. Drawing on resource dependence theory and employing a combination of theoretical analysis and empirical testing, the paper systematically investigates the impact and mechanisms of state-owned capital participation on private enterprises' digital technology innovation. The findings reveal that state-owned capital participation significantly promotes digital technology innovation in private firms. Mechanism analysis further indicates that the alleviation of financing constraints and the mitigation of managerial short-termism play mediating roles in this relationship. Moderation tests show that supply chain stability positively moderates the relationship between state-owned capital participation and digital technology innovation. Heterogeneity analysis demonstrates that the innovation-promoting effect of state-owned capital participation is more pronounced in firms with established bank-enterprise relationships, in high-tech industries, and in regions where local governments place greater emphasis on the digital sector. This study extends the application boundary of resource dependence theory in the field of state-owned capital participation. It offers a new theoretical perspective for understanding the role of mixed-ownership reform in advancing the high-quality development of private enterprises.

1. Introduction

With artificial intelligence, big data, and cloud computing as its key representatives, digital technology has become the core engine driving the high-quality development of China's digital economy. It plays a far-reaching strategic role in building new sources of national competitive advantage and unleashing new drivers of economic growth. As an essential component of China's market economy, private enterprises account for more than 80% of all firms and constitute a crucial force in promoting digital technology innovation. Enhancing their digital innovation capacity is thus vital for achieving the strategic objectives of the national digital economy. However, compared with state-owned enterprises, private firms generally face stronger resource constraints and weaker resilience to risks (Jin et al., 2025). Digital technology innovation is characterized by high complexity, high investment requirements, and high risks (Cen & Lin, 2025), which makes it difficult for most private enterprises to independently shoulder the substantial sunk costs associated with relevant R&D. At the same time, driven by short-term profit pressures, private firms tend to channel their limited resources into areas with faster returns (Xiao et al., 2024), while showing relatively limited willingness to invest in long-cycle and high-uncertainty digital technology R&D. Although market competition mechanisms can, to some extent, stimulate innovation (Hu et al., 2025), private enterprises still urgently require external empowerment to overcome the dual bottlenecks of resource scarcity and insufficient innovation incentives. Consequently, systematically enhancing the digital technology innovation capacity of private firms has become a significant issue directly tied to the nation's digital competitiveness.

In recent years, the role of state capital in China's economy has been undergoing a profound transformation. With the rise of the "investor state" (Hao & Rithmire, 2020), state-owned capital has increasingly penetrated the private sector through equity investment and other channels, giving rise to a new form of state intervention that extends beyond the traditional boundaries of state-owned enterprises. From the perspective of global political economy, this phenomenon is particularly distinctive: the state not only acts as a capital allocator influencing the flow of strategic resources but also reshapes the governance structures, innovation trajectories, and long-term behaviours of private firms through equity participation. Following the State Council's issuance of the Opinions on the Development of a Mixed-Ownership Economy by State-Owned Enterprises in 2015, so-called "reverse mixed-ownership reform," that is, state capital taking stakes in private enterprises, has emerged as an important institutional pathway for fostering deeper integration of diverse forms of capital and invigorating market entities. Existing studies suggest that state capital participation can enhance firms' operational and innovation performance through the dual mechanisms of resource empowerment and governance optimisation (Zhang et al., 2020; Wang et al., 2020). Specifically, equity participation by state capital can effectively ease financing constraints faced by private firms (Guan et al., 2021), strengthen risk resilience, improve ESG performance (Wei & Zhou, 2024), and boost total factor productivity and overall performance (Zhan, 2023).

Nevertheless, the entry of state capital into private enterprises also triggers a series of complex effects. Prior research indicates that although such equity cooperation may provide private firms with stability and access to strategic resources, it may also generate conflicts between governmental and corporate governance logics and objectives (Wehrheim et al., 2020; Xu et al., 2017), induce moral hazard, weaken market discipline (Hao & Rithmire, 2020), and even dampen firms' intrinsic motivation for innovation, thereby suppressing innovation performance (Wan & Yu, 2022). These issues are particularly salient in the context of digital technology innovation, which involves highly uncertain and asset-specific investments. The actual effects of state equity participation thus remain ambiguous: does it truly stimulate the digital innovation capacity of private enterprises, or does it merely serve as a symbolic function aligned with policy directives? Current literature has concentrated mainly on traditional financial or environmental performance, with limited systematic and contextualised exploration of how state capital affects digital innovation within private enterprises. Against this backdrop, this paper takes "reverse mixed-ownership reform", a distinctive institutional practice in China, as its point of departure to examine the impact of state capital participation on the digital technology innovation of private firms, as well as its underlying mechanisms. Building on resource dependence theory, we analyse both the resource effects and governance effects, while incorporating the moderating role of supply chain stability into the analytical framework. In doing so, this study provides more nuanced empirical evidence on the contextual conditions under which state capital shapes innovation-driven development. Moreover, it responds to calls within comparative political economy to investigate new forms of state-business relations further, offering a China-specific theoretical and policy contribution to the global debate on state capital's role in private sector innovation.

Considering this, this study employs data from Chinese A-share listed private enterprises over the period 2013–2023. Drawing on resource dependence theory and applying empirical analysis, it systematically investigates the impact of state capital participation on digital technology innovation in private firms, as well as its underlying mechanisms. The findings show that state capital participation significantly enhances digital technology innovation. Mechanism tests suggest that easing financing constraints and curbing managerial short-termism serve as mediating channels in this relationship. Further analysis reveals that supply chain stability positively moderates the effect of state capital participation on digital technology innovation. Moreover, heterogeneity tests indicate that the positive effect of state capital participation is more pronounced among firms with established bank–firm relationships, in high-tech industries, and in regions where local governments attach greater importance to the digital economy.

The potential marginal contributions of this study are as follows. First, it extends the research scope of mixed-ownership reform to the context of digital innovation, thereby filling the gap in mechanism-oriented and context-specific analyses within this field. Second, it provides both theoretical underpinnings and policy implications for enhancing private firms' digital innovation capabilities through the strategic participation of state capital, and for promoting a high-quality development model of "co-progress between state-owned and private enterprises." Third, and distinct from prior studies, this paper conceptualises supply chain stability as a critical contextual factor influencing private firms' digital technology innovation. By incorporating it as a moderating variable, the study analyses and verifies the positive moderating role of supply chain stability in the relationship between state capital participation and digital technology innovation in private enterprises, offering important insights for private firms' subsequent supply chain management practices.

2. Literature Review

2.1 Factors Influencing Corporate Digital Technology Innovation

As the core engine driving the high-quality development of China's digital economy, digital technology innovation refers to the entire process by which enterprises or organizations integrate digital and physical components systematically to develop new products, new services, or new business models (Yu et al., 2010). Its essential characteristics are reflected in the combinatorial nature of technological structures, the convergence of industrial forms, and the self-evolving nature of innovation progression (Lyytinen et al., 2016). Specifically, it manifests in the synergistic application of technologies such as big data, artificial intelligence, and the Internet of Things, promoting systemic transformation in products, organizations, and business models (Svahn et al., 2017). As a core approach to corporate digital transformation, digital technology innovation can significantly enhance operational efficiency, expand pathways for value creation, and strengthen market competitiveness. However, compared with traditional technological innovation, digital technology innovation still faces significant challenges. On the one hand, due to its high technical complexity and rapid iteration, enterprises must continuously

invest substantial R&D resources, and the resulting innovations are easily imitated, making it challenging to secure exclusive market returns (Guellec & Paunov, 2017).

On the other hand, the acquisition and governance of data elements entail high costs, and the relevant institutional environment remains imperfect. For example, data property rights and cross-border flow regulations are not yet clearly defined, thereby increasing compliance risks for corporate innovation (Berente et al., 2021). For private enterprises, these challenges are even more pronounced. They often face stricter financing constraints and talent shortages, making it challenging to sustain high-intensity R&D investment and the application of advanced digital technologies (Brown et al., 2009). At the same time, they are relatively disadvantaged in data accumulation, algorithm capabilities, and platform ecosystem construction (McIntyre et al., 2017). Without adequate policy support and an enabling innovation environment, the development of digital technology innovation in private enterprises will encounter considerable resistance.

Regarding the factors influencing corporate digital technology innovation, existing studies primarily focus on three levels: the external policy environment, internal firm capabilities and strategies, and cross-organisational collaboration. At the level of the external policy environment, research has concentrated on two types of factors: policy interventions and market mechanisms. Regarding policy interventions, studies based on quasi-natural experiments indicate that institutional arrangements such as intellectual property protection (Wen & Deng, 2023), government digital procurement, government data initiatives, and government data openness help build regional data ecosystems and optimise regional innovation ecosystems. These arrangements provide innovation infrastructure and collaborative environments for small and medium-sized enterprises, thereby significantly influencing digital technology innovation in private enterprises (Tan et al., 2024; Wang et al., 2020; Wang et al., 2023). Regarding market mechanisms, the construction of a unified large market provides broader market space for digital innovation (Aghion et al., 2024), while analyst attention can play an external monitoring role and generate information spillover effects, helping firms improve innovation performance (Palmon & Yezegel, 2012). At the level of internal firm capabilities and strategies, influencing factors can be categorised into governance structures, resource bases, and strategic orientations. In terms of governance structures, top management team characteristics (Dezsö & Ross, 2012) and the appointment of a Chief Digital Officer (Tumbas et al., 2018) can promote digital technology innovation by broadening decision-making perspectives and resource channels. In terms of resource bases, high-quality internal controls (Balsmeier et al., 2017) help optimise resource allocation and enhance innovation willingness. In terms of strategic orientations, entrepreneurial spirit (Jinhuan et al., 2024) and ESG performance (Bolton & Kacperczyk, 2023) provide sustained motivation for digital innovation. Finally, at the level of cross-organisational collaboration, research emphasises the critical role of knowledge sharing and resource integration. Some studies indicate that R&D alliances can promote digital innovation by facilitating knowledge flows, and their effectiveness is moderated by geographical and technological distances (Li et al., 2022).

2.2 State-Owned Capital Participation in Private Enterprises

As an important practical form of China's mixed-ownership reform, state-owned capital participation in private enterprises has attracted considerable academic attention regarding its economic consequences. Existing studies mainly explore this issue from three dimensions: positive effects, negative effects, and nonlinear composite effects. Regarding positive effects, numerous studies indicate that state-owned capital participation can promote the high-quality development of private enterprises through resource and governance effects. The resource effect is manifested in the fact that state-owned capital, as a channel of special political connections, can effectively alleviate institutional constraints faced by private enterprises in credit access, policy support, and industry entry (Berente et al., 2021). For example, state-owned equity participation helps private enterprises obtain bank loans at lower costs (Gu and Zhao, 2022), improve their human resource structure, and more easily gain government subsidies and tax incentives (Xiao et al., 2024). The governance effect is reflected in the balancing role of state-owned shares on the previously highly concentrated equity structures of private enterprises, which curbs majority shareholder expropriation and agency problems (Chen and Rithmire, 2020), thereby enhancing corporate governance, promoting the shift from virtual to real operations, and suppressing opportunistic behaviors such as "greenwashing" (Yan et al., 2024). However, state-owned capital participation may also lead to negative economic consequences. The political attributes of state-owned shareholders may compel enterprises to assume additional policy burdens and social responsibilities, such as excessive employment absorption leading to higher labor costs and tax burdens, thereby dragging down corporate performance (Wehrheim et al., 2020; Bai et al., 2022). In addition, the easy access to government-backed resources may weaken the innovation and development incentives of private enterprises, potentially causing managerial slack or even corruption (Boardman and Vining, 1989), or leading to credit resources being used for financial speculation rather than real investment, exacerbating enterprise financialization. Furthermore, some studies indicate that the relationship between state-owned capital participation and private enterprise innovation outcomes is nonlinear. There exists a critical threshold in the proportion of state-owned equity, and its impact shifts with the degree of participation. For instance, Keoll and Kou (2019) find that the influence of state-owned enterprises on private enterprise innovation follows an inverted U-shape, suggesting that the effect of state-owned capital participation heavily depends on the depth of involvement and the intensity of governance engagement.

2.3 Research Gap

In summary, although existing studies have conducted relatively in-depth investigations into the economic consequences of state-owned capital participation and the drivers of corporate digital technology innovation separately, there exists a significant research gap between the two areas, with a lack of systematic analysis in the specific context of digital technology innovation. Most of the literature still follows the traditional paradigms of "equity participation-performance" or "policy-innovation." It has not fully revealed the complex mechanisms and boundary conditions through which state-owned capital empowers digital innovation in private enterprises. As digital innovation increasingly becomes a key source of corporate core competitiveness, its characteristics of high investment, long cycles, and high uncertainty require firms to have sustained resource supply and stable strategic patience. In this context, focusing solely on the resource injection of state-owned capital while neglecting its governance role, or

discussing general innovation without considering the specificity of digital technologies, can lead to multiple issues. On the one hand, state-owned capital may interfere with firms' R&D autonomy due to "policy burdens," resulting in resource misallocation.

On the other hand, in the absence of effective corporate governance and supply chain coordination, management may use financing support for short-term arbitrage rather than long-term digital investment, potentially exacerbating the shift from real to financialised activities. These situations may suppress the substantive progress of corporate digital innovation, creating a "policy-induced inhibition" dilemma. To address this, the present study, based on resource dependence theory, constructs a mediated path model of state-owned capital participation to financing constraints/managerial short-sightedness to digital technology innovation, and introduces supply chain resilience as a key moderating variable. This approach systematically analyses the mechanisms and contextual boundaries through which state-owned capital participation affects corporate digital innovation, aiming to fill the gaps in theoretical integration and mechanism refinement in existing research, and to provide theoretical foundations and policy implications for effectively leveraging state-owned capital to empower the digital transformation of private enterprises.

3. Theoretical Foundations and Research Hypotheses

3.1 Direct Effect of State-Owned Capital Participation on Private Enterprises Digital Technology Innovation

This study employs resource dependence theory to analyze the direct impact of state-owned capital participation on digital technology innovation in private enterprises. Resource dependence theory emphasizes that the critical resources necessary for organizational survival and development often originate from the external environment; therefore, firms must establish external connections to acquire these resources and reduce environmental uncertainty (Pfeffer & Salancik, 2015). The theory posits that adjustments in equity structure essentially constitute a strategic action by which firms proactively manage resource dependencies. By introducing shareholders with unique resource endowments, firms can enhance their resource acquisition capabilities and modify their strategic decision-making patterns (Hillman et al., 2009).

Applying this theory to analyse the mechanisms through which state-owned capital participation affects corporate digital technology innovation is reasonable. Digital technology innovation activities heavily depend on sustained funding, policy legitimacy, critical technological knowledge, and a stable long-term strategic orientation, resources that private enterprises often face constraints on in dynamic competitive environments. State-owned capital participation is a strategic response by private enterprises to such resource uncertainties. By injecting state-owned equity, it provides key external resources, including policy support, credit access, and innovation networks (Guan et al., 2021), thereby reshaping the firm's resource dependence structure and influencing its digital innovation behaviors. Specifically: First, state-owned capital participation can provide stable strategic resources and legitimacy endorsement. State-

owned equity not only directly offers enterprises preferential credit and R&D subsidies (Gu et al., 2022) but also conveys positive policy signals through government affiliations (Cheng et al., 2019), enhancing firms' credibility and bargaining power in cooperation with financial institutions and innovation partners, effectively reducing financing costs (Guan et al., 2021). This legitimacy improvement helps private enterprises more smoothly enter regulated industries, participate in government digital procurement projects, and engage in major national R&D programs, significantly expanding the resource boundaries and developmental space for digital technology innovation.

Second, state-owned capital participation can optimise firms' knowledge integration and technology acquisition pathways. State-owned capital is often deeply embedded in national innovation systems and research networks. After participation, it can act as a knowledge bridge, facilitating the transfer of advanced digital technologies from universities, state-owned research institutes, and other public R&D organisations to private enterprises (Xu et al., 2025). Through co-establishing laboratories, joint research projects, and personnel exchanges, private enterprises gain access to cutting-edge technological knowledge, share experimental platforms, and connect to broader innovation collaboration networks, thereby effectively reducing the uncertainty and initial fixed costs associated with independent R&D (Cao et al., 2020).

Third, state-owned capital participation can enhance firms' risk-bearing capacity and long-term orientation. Digital technology innovation is characterised by long cycles and high failure rates. The involvement of state-owned capital can provide risk buffers, such as innovation failure compensation and stable order support, to alleviate survival pressure on private enterprises (Jin et al., 2025; Bai et al., 2021), and, through its influence in corporate governance, curb managerial short-termism (Hall & Lerner, 2010). Short-sightedness alleviation by managers encourages sustained investment in long-cycle projects, such as digital infrastructure and core algorithms (Zhan & Zhu, 2021), thereby strengthening firms' willingness and ability to pursue breakthrough digital innovation.

Therefore, state-owned capital participation helps private enterprises overcome structural disadvantages in accessing critical resources, integrating knowledge, and bearing risks. It enables them to overcome resource bottlenecks and uncertainty constraints in digital technology innovation, thereby enhancing innovation performance.

Based on the above analysis, the following hypotheses are proposed:

Hypotheses 1

State-owned capital participation can significantly promote private enterprises digital technology innovation.

3.2 Mechanisms Analysis

Based on resource dependence theory, the participation of state-owned capital can alleviate the resource constraints and environmental uncertainties faced by private enterprises in decision-making,

thereby promoting their digital technology innovation. This theory emphasises that organisations rely on critical external resources to sustain survival and development, and they manage such dependence through forming alliances and adjusting governance structures (Pfeffer & Salancik, 2015). The involvement of state-owned capital constitutes a key strategic response adopted by private enterprises to secure the financial resources, policy support, and long-term strategic orientation urgently needed for digital innovation. Its effects are mainly realised through the following two pathways.

3.2.1 The participation of state-owned capital promotes private enterprise digital technology innovation by alleviating financing constraints.

Resource dependence theory emphasises that organisations must establish external linkages to access critical resources and reduce their reliance on uncertain environments (Pfeffer & Salancik, 2015). As a strategic activity characterised by high investment, long cycles, and significant uncertainty, digital technology innovation is highly dependent on continuous and stable financial support. Financing constraints, however, represent the core resource bottleneck faced by private enterprises in the innovation process. Due to differences in property rights, private firms are often subjected to discriminatory treatment in credit markets (Xiao et al., 2024), making it difficult to obtain sufficient external financing at reasonable costs, which severely limits their capacity for digital innovation. The participation of state-owned capital builds an institutionalised resource-bridging mechanism that significantly improves firms' resource access conditions and dependency structures. Specifically, this mechanism mitigates financing constraints through the following channels: First, state equity plays an important role as a "legitimacy signal." The introduction of state-owned capital conveys positive signals of government recognition and corporate soundness to external stakeholders, substantially enhancing firms' reputation and credibility in capital markets. This signalling effect reduces information asymmetry between investors and firms, thereby attracting more social capital inflows (Cheng et al., 2019). For digital technology firms, which typically lack collateral assets and whose innovation outputs are difficult to value, the credit enhancement brought by state participation is particularly crucial. It not only broadens equity financing channels but also improves the efficiency of capital allocation.

Second, state-owned capital provides a unique form of "credit endorsement" and relational network resources. After participation, enterprises can leverage the governmental background of state shareholders and their close ties with the banking system to establish more stable credit relationships. Creditors such as banks perceive state capital as an implicit guarantee, making them more willing to offer long-term loans with lower interest rates and more flexible financing conditions (Guan et al., 2021). At the same time, state participation also helps firms integrate into broader commercial credit networks, extend payment terms, and optimise cash flow structures, thereby indirectly easing funding pressures during the early stages of innovation. In addition, state-owned capital significantly enhances enterprises' ability to access government-related resources. Under national strategies such as "Digital China," various levels of government have introduced a wide range of targeted subsidies, matching R&D funds, and tax

incentives for digital technology innovation. Firms with state capital participation enjoy informational and compliance advantages in applying for such policies, making it easier for them to secure approvals and continuously obtain subsidies (Guan et al., 2021). These fiscal resources, characterised by low costs and long durations, are particularly well-suited to support the lengthy cycles of digital R&D projects. Ultimately, through these mechanisms, state-owned capital participation helps enterprises establish a more stable, diversified, and low-cost financing system, alleviating the resource dependency dilemma they face in digital innovation. The reduction of financing constraints enables firms to plan long-term R&D projects more confidently, expand the scale of innovation investment, support experimentation and iteration, and foster talent development, thereby providing strong resource support for substantive digital technology innovation.

Based on the above analysis, this paper proposes the following hypothesis:

Hypotheses 2

The participation of state-owned capital promotes private enterprises digital technology innovation by alleviating financing constraints.

3.2.2 The participation of state-owned capital promotes private enterprise digital technology innovation by curbing managerial short-termism.

Resource dependence theory suggests that the environmental uncertainty faced by organisations significantly influences their strategic decisions and temporal orientation (Pfeffer & Salancik, 2015). Digital technology innovation is characterised by long investment cycles and high uncertainty in returns, and its success relies heavily on managers' long-term strategic patience and willingness to bear risks. However, in the absence of effective governance and resource assurance, managers of private firms often tend to avoid long-term R&D investments due to performance evaluation pressures, career reputation risks, and external market volatility, thereby exhibiting pronounced short-termist tendencies (Hall & Lerner, 2010), which severely restricts firms' ability to pursue digital technology innovation. The participation of state-owned capital improves corporate governance structures and external dependency environments, effectively curbing managerial short-termism. The main mechanisms include the following aspects: First, state-owned capital enhances governance oversight and strategic guidance. Through appointing directors and participating in board decision-making, state shareholders strengthen supervision over the formulation and implementation of corporate strategies. The governance role represented by state capital emphasises not only financial returns but also policy compliance, technological innovation capability, and long-term competitiveness (Leutert, 2016). This governance model effectively constrains managers from cutting innovation investment in pursuit of short-term stock price performance or profit targets, thereby encouraging firms to allocate more resources to strategically significant digital technology R&D.

Second, the policy attributes and resource background of state-owned capital help firms build a more stable external operating environment, thereby reducing the uncertainty faced by managers. The involvement of state-owned capital usually implies that firms establish stronger ties with the government, state-owned financial institutions, and other critical resource providers. Such “institutional linkages” can provide policy support, order guarantees, or resource coordination during times of crisis (Bai et al., 2021). When firms’ capacity to withstand external risks is strengthened, managers become less concerned about the impact of market volatility or resource disruptions on short-term operations. They are thus more willing to implement long-cycle digital technology innovation projects, avoiding the sacrifice of long-term competitiveness due to excessive risk aversion.

Finally, the participation of state-owned capital reshapes managerial incentive structures and time preferences. State shareholders focus more on sustainable development and alignment with national strategies, and such orientation can be transmitted to managers through mechanisms such as compensation contract design and adjustment of performance evaluation indicators (Xiao et al., 2024). For instance, incorporating innovation achievements and breakthroughs in core technologies into executive appraisal systems weakens incentive models solely based on short-term profits or stock price performance. Under such institutional arrangements, managers are more motivated to engage in long-term innovation activities such as digital technology, thereby preventing the misalignment between their personal interests and the firm’s long-term development goals.

In summary, the participation of state-owned capital effectively curbs managerial short-termism by strengthening governance oversight, enhancing environmental stability, and adjusting incentive structures. It alleviates behavioural constraints and uncertainty dependencies in managers’ digital technology innovation decisions, thereby encouraging firms to more firmly engage in digital technology R&D and providing institutional safeguards for sustainable innovation. Therefore, by easing critical financing constraints in resource dependence relationships and improving the psychological environment for decision-making, state-owned capital empowers private firms to pursue digital technology innovation.

Based on the above analysis, this paper proposes the following hypothesis:

Hypotheses 3

The participation of state-owned capital promotes private enterprises digital technology innovation by curbing managerial short-termism.

3.3 Moderating Mechanism of Supply Chain Stability

Based on resource dependence theory, supply chain stability represents a firm’s critical capability to manage external dependencies and cope with environmental uncertainty along the vertical dimension, constituting an important contextual condition influencing the empowerment effect of state-owned capital participation on digital technology innovation in private enterprises. This paper posits that the higher the level of supply chain stability, the stronger the promoting effect of state-owned capital

participation on digital technology innovation. Resource dependence theory emphasises that organisations need to adjust their internal structures and external relationships to manage the flow of critical resources and buffer environmental fluctuations (Pfeffer & Salancik, 2015). Supply chain stability reflects a firm's ability to maintain a stable resource supply, quickly adjust, and adapt collaboratively when facing external shocks (Soni et al., 2014), and its level directly determines whether firms can effectively transform the various resources injected by state-owned capital into sustainable digital technology innovation outcomes.

First, from the perspective of reducing environmental dependence and uncertainty, high supply chain stability provides private enterprises with more stable input and output channels, effectively mitigating operational uncertainty caused by supply disruptions or demand fluctuations. Following state-owned capital participation, firms can avoid diverting additional resources to address sudden supply chain disturbances, thereby focusing more on long-term technological planning and R&D activities, which enhances the resource allocation efficiency of state-owned capital in digital innovation.

Second, from the perspective of optimising resource acquisition and information integration, a stable supply chain is characterised by long-term cooperation, trust accumulation, and information sharing (Ersahin et al., 2024). Supply chain stability not only helps firms reduce transaction costs and improve capital allocation (Minetti et al., 2018) but also strengthens knowledge exchange and responsiveness between upstream and downstream partners. In this context, state-owned capital can fully leverage its role as an information bridge and resource coordinator, timely identify innovation opportunities, and accurately channel technological resources, thereby reducing information asymmetry and resource misallocation in the innovation process and increasing the likelihood of successful digital technology innovation.

Finally, from the perspective of promoting cross-organizational collaboration and constructing an innovation ecosystem, supply chain stability provides institutional support for deep innovation cooperation (Kang et al., 2018). State-owned capital can leverage this stable cooperative foundation to facilitate the development of a collaborative innovation network centered on private enterprises and integrating upstream and downstream firms as well as research institutions. Such networks jointly tackle key digital technologies, enhancing the overall effectiveness and risk resilience of the innovation system.

Therefore, in environments with high supply chain stability, state-owned capital participation can more fully exert its resource-empowering and governance-guiding roles, helping firms build a more robust and agile innovation resource base, thereby strengthening the intensity and sustainability of digital technology innovation.

Based on the above analysis, this paper proposes the following hypothesis:

Hypotheses 4

Supply chain stability positively moderates the relationship between state-owned capital participation and private enterprises digital technology innovation.

4. Research Design

4.1 Data Sources

This study focuses on private companies listed on the A-share market from 2013 to 2023. The year 2013 was chosen as the starting point because the Third Plenary Session of the 18th Central Committee of the Communist Party of China explicitly proposed for the first time to “encourage the development of mixed-ownership enterprises controlled by non-state capital,” marking the beginning of the “reverse mixed-ownership reform.” In addition, to improve the reliability of the study, we followed the practices of prior research and processed the data as follows: (1) excluding firms in the financial industry; (2) excluding ST, *ST, and firms with serious data omissions; (3) excluding samples of firms converted from state-owned to private ownership; and (4) winsorizing all continuous variables at the 1% level on both ends to mitigate the potential impact of extreme values. After these treatments, a total of 12,217 observations from 2,228 private listed companies were obtained. Unless otherwise noted, the variable data used in subsequent analyses are sourced from the CSMAR database and the WIND database.

4.2 Variable Definitions

4.2.1 Dependent Variable: Enterprises Digital Technology Innovation (*DTI*)

Considering that a firm’s patent portfolio can reflect its level of technological innovation (He et al., 2018), this study matches the main classification numbers of patents with the digital economy industry to identify whether a patent qualifies as a digital patent. Digital technology patents are then used to measure the level of digital technology innovation in private enterprises. The specific procedure is as follows:

Step 1

Based on the Statistical Classification of the Digital Economy and Its Core Industries (2021) published by the National Bureau of Statistics and the Reference Table of the Correspondence between International Economic Classification and National Economic Industry Classification (2018) issued by the State Intellectual Property Office, the study matches the four-digit Standard Industrial Classification codes (SIC4) with IPC groups provided by the International Patent Classification (IPC) system to identify patent types belonging to the digital technology innovation domain.

Step 2

The number of identified digital technology patent applications is aggregated at the firm-year level, and then 1 is added before taking the natural logarithm. This transformed measure serves as the indicator of a firm's digital technology innovation.

4.2.2 Explanatory Variable: State-Owned Capital Participation (*State1*)

Following the approach of previous studies, this paper measures state-owned capital participation using both a continuous variable and a dummy variable (Xiao et al., 2024). Specifically, for the continuous variable, the proportion of shares held by state-owned shareholders (*State1*) is used as a proxy for state-owned capital participation, calculated as the sum of the shareholding ratios of state-owned shareholders among the top ten shareholders. For the dummy variable, the presence of a major state-owned shareholder (*State2*) is used as a proxy, coded as 1 if the shareholding ratio of state-owned shareholders among the top ten shareholders reaches 10%^[1] or more, and 0 otherwise. The continuous variable is employed in the baseline regression, while the dummy variable is used for robustness checks.

4.2.3 Mediating Variables

(1) Financing Constraints (*KZ*)

This study follows the approach of Kaplan and Zingales (1997) to measure corporate financing constraints, using the KZ index to quantify the degree of financing constraints faced by private enterprises. A higher KZ index indicates more severe financing constraints.

(2) Managerial Short-Termism (*Myopia*)

This study measures managerial short-termism using the “Managerial Short-Termism Index” disclosed in the WinGo financial database. First, the Management Discussion and Analysis (MD&A) sections of annual reports of Chinese listed companies are used as the base corpus, and seed words reflecting short-term orientation, such as “within the year”, “intra-day” and “immediately”, are selected based on the characteristics of the language context. Second, the Word2Vec machine learning model, employing the CBOW neural network algorithm, is applied to analyse the contextual semantics of the MD&A texts, automatically expanding the set of words highly associated with the seed words. After expert verification to remove irrelevant terms, a short-termism dictionary containing 43 terms is formed. Finally, the frequency of these terms in the MD&A text is calculated, and the proportion is multiplied by 100 to obtain the managerial short-termism index.

4.2.4 Moderating Variable: Supply Chain Stability (*Stability*)

This study draws on existing research to measure supply chain stability using overall supply chain stability (Hao & Yan, 2025). The specific procedure is as follows:

Step 1

The number of the top five suppliers from the previous year that still appear in the top five suppliers list in the current year is divided by 5, serving as a proxy variable for supplier stability.

Step 2

The number of the top five customers from the previous year that still appear in the top five customers list in the current year is divided by 5, serving as a proxy variable for customer stability.

Step 3

The mean of supplier relationship stability and customer relationship stability (*Stability*) is taken as the proxy variable for overall supply chain stability in this study.

4.2.5 Control Variables

To enhance the accuracy of the study’s conclusions, this paper controls for the following factors that may affect digital technology innovation in private enterprises: Firm Size (*Size*); Firm Age (*Age*); Leverage (*Leverage*); Return on Assets (*ROA*); Cash Flow (*Cashflow*); Board Size (*Board*); Firm Growth (*Growth*); Shareholding Ratio of the Largest Shareholder (*Top1*). The specific definitions of these variables are presented in Table 1.

Table 1
Variable Definitions

Variable Type	Variable Name	Variable Symbol	Variable Definition
Explained Variable	Corporate Digital Technology Innovation	<i>DTI</i>	Ln (1 + number of digital technology patent applications)
		<i>DTIA</i>	Ln (1 + number of digital technology patents granted)
Explanatory Variable	State-owned Capital Participation	<i>State1</i>	the sum of shareholding ratios of state-owned shareholder groups among the top ten shareholders
		<i>State2</i>	whether the shareholding of state-owned shareholder groups among the top ten shareholders reaches 10%
mediating variable	Financing Constraints	<i>KZ</i>	Kaplan-Zingales index
	Managerial Short-termism	<i>Myopia</i>	the proportion of “short-term oriented” words in the MD&A × 100
moderating variable	supply chain stability	<i>Stability</i>	average of supplier and customer relationship stability
control variable	Firm Size	<i>Size</i>	Ln (total assets at year-end)
	Firm Age	<i>Age</i>	Ln (firm age)
	Leverage	<i>Leverage</i>	the ratio of total liabilities to total assets at the end of the year
	Return on Assets	<i>ROA</i>	the ratio of net profit to total assets at the end of the year
	Cash Flow	<i>Cashflow</i>	the ratio of net cash flow from operating activities to current liabilities
	Board Size	<i>Board</i>	Ln (board size)
	Firm Growth	<i>Growth</i>	main business growth rate
	Shareholding Ratio of the Largest Shareholder	<i>Top1</i>	the proportion of total shares held by the largest shareholder

4.3 Model Construction

To examine the impact of state-owned capital participation on digital technology innovation in private enterprises, this study constructs the following model:

$$DTI_{i,t} = \alpha_0 + \alpha_1 State1_{i,t} + \alpha_2 Controls_{i,t} + Year + Firm + \epsilon_{i,t}$$

Where i represents the firm and t represents the year; the dependent variable DTI represents the private enterprises digital technology innovation indicator; the explanatory variable State1 represents the shareholding ratio of state-owned shareholders; Controls includes all control variables considered in this study; Firm and Year represent firm fixed effects and year fixed effects, respectively; ϵ represents the random error term.

4.4 Descriptive Statistical Analysis

The descriptive statistics are presented in Table 2. The dependent variable DTI has a mean of 2.095 and a standard deviation of 1.228, with a minimum of 0 and a maximum of 8.109, indicating considerable variation in digital technology innovation levels across different private enterprises. The key explanatory variable State1 has a mean of 0.026, with a minimum of 0 and a maximum of 0.471, suggesting that the overall level of state-owned capital participation in Chinese private enterprises is relatively low, yet there is substantial variation among firms. The mean of KZ is 0.9723, with a minimum of -12.787 and a maximum of -10.433, indicating significant differences in the financing constraints faced by listed companies during the sample period. The mean of Myopia is 0.034, with a minimum of 0 and a maximum of 0.199, showing considerable variation in managerial short-termism across firms. The mean of Stability is 0.544, indicating that in the sample firms, at least two customers or suppliers changed over two consecutive years; the minimum is 0, and the maximum is 1, reflecting substantial differences in supply chain stability among firms. The descriptive statistics for the remaining control variables are all within normal ranges.

Table 2
Descriptive Statistics

Variables	N	Mean	St. D	Min	Median	Max
<i>DTI</i>	12217	2.095	1.228	0	1.946	8.109
<i>DTIA</i>	12217	1.556	1.291	0	1.386	5.537
<i>State1</i>	12217	0.026	0.059	0	0	0.471
<i>State2</i>	12217	0.562	0.496	0	1	1
<i>KZ</i>	12217	0.9723	2.151	-12.787	1.118	10.433
<i>Myopia</i>	12217	0.034	0.031	0	-0.026	0.199
<i>Stability</i>	12217	0.544	0.339	0	0.800	1
<i>Size</i>	12217	22.010	1.072	19.805	21.863	26.440
<i>Leverage</i>	12217	0.376	0.181	0.049	0.369	0.916
<i>ROA</i>	12217	0.041	0.068	-0.239	0.043	0.219
<i>Growth</i>	12217	0.189	0.399	-0.678	0.124	4.029
<i>Cashflow</i>	12217	0.048	0.064	-0.157	0.045	0.232
<i>Age</i>	12217	2.075	0.813	0	2.079	3.689
<i>Board</i>	12217	2.072	0.186	1.609	2.197	2.485
<i>Top1</i>	12217	25.282	16.571	0.076	24.850	67.975

5. Empirical Analysis

5.1 Baseline Regression

The baseline regression results of this study are presented in Table 3. Columns (1) to (4) respectively show the stepwise regression results: first including only the key explanatory variable, then adding a series of control variables, further controlling for time fixed effects, and finally controlling for both time and firm fixed effects. As shown in Table 3, the regression coefficients of State1 on DTI are all significantly positive, indicating that firms with a higher degree of state-owned capital participation exhibit relatively higher levels of digital technology innovation. The regression results in Column (4) show that, after controlling for a series of control variables as well as time and firm fixed effects, the coefficient of the key explanatory variable State1 is 0.845 and significantly positive at the 1% level. This result implies that for private enterprises, a 1% increase in the shareholding ratio of state-owned capital is associated with a 0.845% increase in the level of digital technology innovation. These findings indicate that the introduction of state-owned capital into private enterprises has a significant positive impact on digital technology innovation. This conclusion is also consistent with **Hypothesis 1** of this study.

Table 3
Baseline Regression Results

Variables	(1)	(2)	(3)	(4)
	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>
<i>State1</i>	3.225*** (0.1870)	2.628*** (0.1865)	2.923*** (0.1837)	0.845*** (0.2411)
<i>Size</i>		0.377*** (0.0126)	0.340*** (0.0127)	0.406*** (0.0223)
<i>Age</i>		-0.146*** (0.0164)	-0.0293* (0.0174)	0.152*** (0.0247)
<i>Leverage</i>		-0.171** (0.0712)	-0.239*** (0.0699)	-0.144 (0.0888)
<i>ROA</i>		-0.213 (0.1947)	0.00861 (0.1918)	-0.0807 (0.1545)
<i>Cashflow</i>		-0.648*** (0.1848)	-0.728*** (0.1833)	-0.229 (0.1463)
<i>Growth</i>		0.0972*** (0.0272)	0.107*** (0.0269)	-0.0386* (0.0202)
<i>Board</i>		-0.230*** (0.0579)	-0.317*** (0.0571)	0.185** (0.0759)
<i>Top1</i>		0.00494*** (0.0008)	-0.00375*** (0.0009)	0.00218* (0.0013)
Year FE	NO	NO	NO	YES
Firm FE	NO	NO	YES	YES
Constant	2.011*** (0.0120)	-5.536*** (0.2593)	-4.550*** (0.2644)	-7.665*** (0.4814)
N	12217	12217	12217	12217
R2	0.0238	0.121	0.158	0.790
Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Robust standard errors are reported in parentheses. Unless otherwise noted, the same applies throughout.				

5.2 Endogeneity and Robustness Test

5.2.1 Endogeneity Test

(i) Instrumental Variable (IV)

Reverse causality between the key explanatory variable and the dependent variable is an important source of endogeneity. While state-owned capital participation can enhance digital technology innovation in private enterprises, private firms with higher levels of digital technology innovation may also be more attractive to state-owned investors. To mitigate potential endogeneity, this study uses the industry-level average proportion of state-owned capital participation in the firm's industry in the same year as an instrumental variable for state-owned capital participation (IV). The rationale is as follows: On one hand, state-owned capital tends to support nationally prioritized industries^[2]; therefore, the average level of state-owned capital participation in a firm's industry is correlated with the firm's own level of state-owned capital participation, satisfying the relevance condition. On the other hand, the industry-level average of state-owned capital participation in a given year is unlikely to directly affect a private firm's digital technology innovation, satisfying the exclusion restriction. The first-stage regression results are presented in Column (1) of Table 4, where the IV coefficient is significantly positive, indicating a positive correlation between a private enterprise and the average level of state-owned capital participation in its industry. Moreover, the Cragg–Donald Wald F statistic in the first stage is 177.713, far exceeding the critical value of 16.38 at the 10% significance level for the Stock-Yogo weak IV test, indicating that there is no weak instrument problem.

Table 4
Endogeneity Analysis: IV, Heckman, and PSM

Variables	(1)	(2)	(3)	(4)	(5)
	IV		Heckman		PSM
	<i>State1</i>	<i>DTI</i>	<i>State1_dum</i>	<i>DTI</i>	<i>DTI</i>
<i>State1</i>		4.1409**		1.5834***	0.6552**
		(1.7423)		(0.3278)	(0.2702)
<i>IV</i>	0.4117***				
	(0.0309)				
<i>Nose</i>			-0.0243**		
			(0.0096)		
<i>IMR</i>				0.3790	
				(0.3753)	
<i>Size</i>	-0.0030***	0.4162***	0.2951***	0.5357***	0.4249***
	(0.0010)	(0.0231)	(0.0149)	(0.0781)	(0.0268)
<i>Age</i>	-0.0027**	0.1596***	0.2733***	0.1194	0.1724***
	(0.0011)	(0.0253)	(0.0203)	(0.0786)	(0.0329)
<i>Leverage</i>	0.0063	-0.1676*	-0.3552***	-0.3169**	-0.1411
	(0.0039)	(0.0906)	(0.0804)	(0.1506)	(0.1115)
<i>ROA</i>	-0.0123*	-0.0309	0.3747*	0.1546	0.0099
	(0.0067)	(0.1583)	(0.2196)	(0.2848)	(0.1958)
<i>Cashflow</i>	-0.0015	-0.2273	0.2699	-0.1864	-0.1766
	(0.0064)	(0.1479)	(0.2117)	(0.1627)	(0.1833)
<i>Growth</i>	0.0011	-0.0433**	0.0441	-0.0823***	-0.0357
	(0.0009)	(0.0206)	(0.0308)	(0.0297)	(0.0246)
<i>Board</i>	0.0251***	0.0984	0.2891***	0.2539***	0.2306**
	(0.0033)	(0.0891)	(0.0655)	(0.0978)	(0.0944)
<i>Top1</i>	-0.0002***	0.0029**	0.0019*	0.0051***	0.0019
	(0.0001)	(0.0013)	(0.0010)	(0.0018)	(0.0015)
Year FE	YES	YES	YES	YES	YES

Variables	(1)	(2)	(3)	(4)	(5)
	IV		Heckman		PSM
	<i>State1</i>	<i>DTI</i>	<i>State1_dum</i>	<i>DTI</i>	<i>DTI</i>
Firm FE	YES	YES	YES	YES	YES
Constant	0.0288 (0.0209)	-3.129*** (0.3378)	-7.2996*** (0.3672)	-10.2864*** (2.3215)	-9.9449*** (0.6355)
N	12217	12217	10724	10228	9027
R ²	0.8260	0.1588		0.7952	0.8215
PseudoR ²			0.0928		

(ii) Heckman Two-Stage Model

Considering that certain unobservable factors may influence state-owned capital participation, this study employs the Heckman two-stage model to mitigate potential sample selection bias. In the first stage, the dependent variable is a dummy variable indicating whether a private enterprise receives state-owned capital participation in the current year (*State1_dum*). Given that in regions where private economic development is relatively lagging, state-owned enterprises are more likely to assign shareholders to local private firms to promote local private economic development, this study uses the level of regional private economic development (*Nose*) as the exclusion restriction variable. A Probit regression is then performed to calculate the inverse Mills ratio (IMR). The regression results are presented in Column (3) of Table 4, where the coefficient of *Nose* is significantly negative, confirming the relevance of the exclusion restriction variable with the endogenous variable. In the second stage, IMR is included as a control variable in the baseline regression model. The results are shown in Column (4) of Table 5. The coefficient of the key explanatory variable, *State1*, remains significantly positive at the 1% level, while the coefficient of IMR is not significant. These findings indicate that potential sample selection bias in this study is not severe.

(iii) Propensity Score Matching (PSM)

Considering that certain observable factors may influence state-owned capital participation, this study employs Propensity Score Matching (PSM) to mitigate potential sample self-selection issues. Specifically, the sample is divided into a treatment group and a control group based on whether private enterprises receive state-owned capital participation. The control variables from the baseline regression model are used as covariates for 1:1 nearest-neighbour matching. After matching, the distributions of the treatment and control groups are nearly identical. Column (5) of Table 4 presents the results of re-estimating the baseline regression model using the matched sample. The coefficient of *State1* remains

significantly positive at the 1% level, indicating that the study’s conclusions remain robust even after addressing potential sample self-selection issues.

5.2.2 Robustness Test

(i) Alternative Measures of Core Variables

To avoid the potential impact of variable measurement methods on the regression results, this study replaces the measures of state-owned capital participation and digital technology innovation in private enterprises. For state-owned capital participation, a dummy variable (State2) is used as a robustness indicator, which takes the value of 1 if the shareholding ratio of state-owned shareholders among the top ten shareholders reaches 10%, and 0 otherwise. For digital technology innovation in private enterprises, the robustness indicator is the natural logarithm of the number of digital technology innovation patents plus one (DTIA). As shown in Columns (1) and (2) of Table 5, the coefficients of State2 and DTIA are both significantly positive at the 1% level, indicating that the study’s conclusions remain robust.

(ii) Controlling for High-Dimensional Fixed Effects

In the baseline regression described earlier, this study controlled for year fixed effects, firm fixed effects, and a series of relevant control variables to mitigate the impact of omitted variables on the results. Considering that certain industry-level factors, such as tax incentives and industrial policies, may affect the level of digital technology innovation in private enterprises, this study further controls for industry-year fixed effects (Ind×Year) and re-estimates the regression. The results are presented in Column (3) of Table 5. Moreover, digital technology innovation in private enterprises may also be influenced by regional economic conditions. Therefore, city-year fixed effects (City×Year) are additionally controlled, and the regression results are shown in Column (4) of Table 5. Furthermore, Column (5) of Table 5 simultaneously controls for both city-year and industry-year fixed effects. From Columns (3) to (5) of Table 5, the coefficient of State1 remains significantly positive, indicating that the study’s conclusions are robust.

Table 5

Robustness Check I: Alternative Measures of Core Variables and High-Dimensional Fixed Effects

Variables	(1)	(2)	(3)	(4)	(5)
	replace the measurement of the core variable		include high-dimensional fixed effects as controls		
	<i>DTIA</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>
<i>State1</i>	0.6498**		0.6903***	0.8837***	0.6889**
	(0.2930)		(0.2479)	(0.2701)	(0.2806)
<i>State2</i>		0.1747***			
		(0.0192)			
<i>Size</i>	0.3366***	0.3980***	0.4260***	0.4417***	0.4850***
	(0.0270)	(0.0222)	(0.0241)	(0.0252)	(0.0274)
<i>Age</i>	0.1649***	0.1234***	0.1181***	0.1114***	0.0707**
	(0.0301)	(0.0248)	(0.0259)	(0.0275)	(0.0289)
<i>Leverage</i>	0.1200	-0.1391	-0.0978	-0.1498	-0.1277
	(0.1079)	(0.0884)	(0.0935)	(0.0980)	(0.1041)
<i>ROA</i>	-0.7029***	-0.1279	0.0069	-0.0557	-0.0147
	(0.1877)	(0.1539)	(0.1639)	(0.1684)	(0.1789)
<i>Cashflow</i>	-0.0176	-0.2424*	-0.2040	-0.1933	-0.1412
	(0.1778)	(0.1458)	(0.1527)	(0.1592)	(0.1663)
<i>Growth</i>	-0.0247	-0.0310	-0.0443**	-0.0418*	-0.0493**
	(0.0246)	(0.0202)	(0.0217)	(0.0224)	(0.0239)
<i>Board</i>	0.2936***	0.2010***	0.1943**	0.1700**	0.1557*
	(0.0923)	(0.0754)	(0.0780)	(0.0830)	(0.0860)
<i>Top1</i>	0.0029*	0.0020	0.0020	0.0031**	0.0023
	(0.0015)	(0.0013)	(0.0013)	(0.0014)	(0.0015)
Year FE	YES	YES	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES
Ind×Year FE	NO	NO	YES	NO	YES

Variables	(1)	(2)	(3)	(4)	(5)
	replace the measurement of the core variable		include high-dimensional fixed effects as controls		
	<i>DTIA</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>
City×Year FE	NO	NO	NO	YES	YES
Constant	-6.8765*** (0.5850)	-7.5316*** (0.4795)	-7.8798*** (0.5351)	-8.1489*** (0.5562)	-8.9641*** (0.6058)
N	12217	12217	12217	12217	12217
R2	0.7190	0.7915	0.7805	0.7954	0.8119

(iii) Excluding the Impact of Special Samples

To eliminate the potential influence of special samples on the study's conclusions, this study sequentially excludes the following types of samples. First, the COVID-19 outbreak at the end of 2019 had a severe negative impact on enterprises. To rule out the potential interference of the pandemic on digital technology innovation in private enterprises, the sample from 2019 to 2022 is excluded, and the effect of state-owned capital participation on digital technology innovation is re-examined. The regression results are presented in Column (1) of Table 6, and the conclusions remain robust. Second, considering the unique socio-economic development of the four municipalities directly under the central government, Beijing, Shanghai, Tianjin, and Chongqing, the level of digital technology innovation in private enterprises in these regions may differ from other areas. Therefore, the samples from these four municipalities are excluded for a robustness check. The results are shown in Column (2) of Table 6, confirming the robustness of the conclusions. Third, industries with a high intensity of digital elements may have certain peculiarities that could interfere with the study. To mitigate this effect, the samples from the Information Transmission, Software, and Information Technology Services industries are excluded. The results, presented in Column (3) of Table 6, indicate that the conclusions remain robust.

Table 6
Robustness Check II: Excluding the Impact of Special
Samples

Variables	(1)	(2)	(3)
	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>
<i>State1</i>	0.7068** (0.2880)	0.8240*** (0.2673)	0.8803*** (0.2455)
<i>Size</i>	0.3613*** (0.0294)	0.3982*** (0.0241)	0.4061*** (0.0233)
<i>Age</i>	0.1586*** (0.0382)	0.1508*** (0.0270)	0.1614*** (0.0257)
<i>Leverage</i>	0.0619 (0.1174)	-0.1519 (0.0982)	-0.1085 (0.0936)
<i>ROA</i>	0.0781 (0.2128)	-0.0708 (0.1713)	-0.1357 (0.1667)
<i>Cashflow</i>	-0.2842 (0.2048)	-0.0874 (0.1598)	-0.1348 (0.1538)
<i>Growth</i>	-0.0000 (0.0274)	-0.0361 (0.0227)	-0.0389* (0.0219)
<i>Board</i>	0.2183** (0.1015)	0.2254*** (0.0838)	0.1836** (0.0798)
<i>Top1</i>	0.0010 (0.0017)	0.0029** (0.0014)	0.0014 (0.0013)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
Constant	-6.8280*** (0.6348)	-7.6375*** (0.5230)	-7.7082*** (0.5041)
N	7705	10029	11038
R ²	0.8184	0.7973	0.7971

6. Mechanism Analysis

6.1 Mechanism Analysis of the Impact of State-Owned Capital Participation on Private Enterprises Digital Technology Innovation

6.1.1 Financing Constraints

Alleviating financing constraints can significantly reduce the financial pressure faced by private enterprises during R&D activities, thereby promoting their digital technology innovation. The results of the mechanism test for financing constraints are presented in Columns (1) and (2) of Table 7. In Column (1), the estimated coefficient of State1 is significantly negative at the 1% level, indicating that state-owned capital participation can alleviate the financing constraints faced by private enterprises. In Column (2), the coefficient of State1 is significantly positive. Meanwhile, the coefficient of KZ is significantly negative, suggesting that state-owned capital participation can relieve financing constraints in private enterprises and thereby promote their digital technology innovation. Moreover, a Sobel test was conducted, and the Z statistic for KZ is 6.578, which is significantly positive at the 1% level. These results support **Hypothesis 2**, confirming that state-owned capital participation can alleviate financing constraints in private enterprises, thereby promoting their digital technology innovation.

6.1.2 Managerial Myopia

Managerial Myopia can reduce the investment efficiency of digital technology innovation projects and decrease R&D inputs, thereby lowering the level of digital technology innovation in private enterprises. The results of the mechanism test for managerial Myopia are presented in Columns (3) and (4) of Table 7. In Column (3), the estimated coefficient of State1 is significantly negative at the 1% level, indicating that state-owned capital participation can suppress managerial Myopia in private enterprises. In Column (4), the coefficient of State1 is significantly positive. Meanwhile, the coefficient of Myopia is significantly negative, suggesting that state-owned capital participation can curb managerial Myopia in private enterprises and thereby promote their digital technology innovation. Furthermore, a Sobel test was conducted, and the Z statistic for Myopia is 5.399, which is significantly positive at the 1% level. These results support **Hypothesis 3**, confirming that state-owned capital participation can suppress managerial Myopia and consequently enhance digital technology innovation in private enterprises.

Table 7
Results of the Mechanism Test

Variables	(1)	(2)	(3)	(4)
	<i>KZ</i>	<i>DTI</i>	<i>Myopia</i>	<i>DTI</i>
<i>State1</i>	-6.3033*** (0.3917)	0.7368*** (0.2445)	-0.0267*** (0.0091)	0.8251*** (0.2412)
<i>KZ</i>		-0.0172*** (0.0065)		
<i>Myopia</i>				-0.7553*** (0.2801)
<i>Size</i>	-0.6695*** (0.0362)	0.3946*** (0.0227)	-0.0028*** (0.0008)	0.4040*** (0.0223)
<i>Age</i>	0.6360*** (0.0402)	0.1629*** (0.0251)	0.0005 (0.0009)	0.1523*** (0.0247)
<i>Leverage</i>	5.3884*** (0.1442)	-0.0512 (0.0955)	0.0021 (0.0034)	-0.1423 (0.0888)
<i>ROA</i>	-2.8467*** (0.2510)	-0.1296 (0.1556)	-0.0245*** (0.0058)	-0.0992 (0.1546)
<i>Cashflow</i>	-13.6715*** (0.2377)	-0.4643*** (0.1713)	-0.0009 (0.0055)	-0.2299 (0.1463)
<i>Growth</i>	-0.2245*** (0.0329)	-0.0424** (0.0203)	-0.0019** (0.0008)	-0.0400** (0.0202)
<i>Board</i>	0.1125 (0.1233)	0.1868** (0.0759)	0.0011 (0.0029)	0.1857** (0.0759)
<i>Top1</i>	0.0029 (0.0021)	0.0022* (0.0013)	0.0001 (0.0000)	0.0022* (0.0013)
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Constant	12.1993*** (0.7820)	-7.4550*** (0.4877)	0.0887*** (0.0182)	-7.5978*** (0.4818)

Variables	(1)	(2)	(3)	(4)
	<i>KZ</i>	<i>DTI</i>	<i>Myopia</i>	<i>DTI</i>
N	12217	12217	12217	12217
R ²	0.8192	0.7901	0.5267	0.7901
Sobel Test	6.578***		3.417***	

6.2 Test of the Moderating Effect of Supply Chain Stability

This section primarily examines the moderating effect of supply chain stability on the impact of state-owned capital participation on digital technology innovation in private enterprises. The results are presented in Table 8. The interaction term (State1×Stability) is significantly positive at the 1% level, confirming the positive moderating role of supply chain stability. That is, the stronger the supply chain stability of a private enterprise, the greater the promoting effect of state-owned capital participation on its digital technology innovation. Therefore, **Hypothesis 4** is supported.

Table 8
Results of the Moderating Effect
Test

Variables	<i>DTI</i>
<i>State1</i>	0.0924 (0.3726)
<i>Stability</i>	0.2698*** (0.0292)
<i>State1×Stability</i>	1.4412*** (0.5119)
<i>Size</i>	0.4016*** (0.0221)
<i>Age</i>	0.1385*** (0.0246)
<i>Leverage</i>	-0.1564* (0.0882)
<i>ROA</i>	-0.0370 (0.1534)
<i>Cashflow</i>	-0.2484* (0.1453)
<i>Growth</i>	-0.0319 (0.0201)
<i>Board</i>	0.1941** (0.0754)
<i>Top1</i>	0.0020 (0.0013)
Year FE	YES
Firm FE	YES
Constant	-7.6568*** (0.4782)

Variables	<i>DTI</i>
N	12217
R ²	0.7929

7. Heterogeneity Analysis

7.1 Whether the Bank-Enterprise Relationship Exists

From the perspective of bank-enterprise relationships, when a firm has such a relationship, it can significantly reduce information asymmetry with banks and more easily secure higher credit lines (Wang et al., 2022), effectively alleviating financial pressure during the R&D process of digital technology innovation and thereby increasing innovation output. Based on this, it is inferred that the promoting effect of state-owned capital participation on digital technology innovation is more pronounced in private enterprises without bank-enterprise relationships. To test this theoretical inference, this study follows the approach of previous research (Zhai et al., 2014). It divides the sample into two groups: those with bank-enterprise relationships and those without, conducting group regressions accordingly. A firm is considered to have a bank-enterprise relationship if it meets any of the following three conditions: a senior executive has a banking background, the firm holds shares in a bank, or a bank holds shares in the firm; otherwise, it is considered not to have such a relationship. The regression results are presented in Columns (1) and (2) of Table 9. The results show that in the sample of private enterprises with bank-enterprise relationships, the coefficient of State1 is not significant. In contrast, in the sample without bank-enterprise relationships, it is significantly positive. This result indicates that, compared with firms with bank-enterprise relationships, the effect of state-owned capital participation in promoting digital technology innovation is more pronounced in private enterprises without such relationships, consistent with the theoretical inference above.

7.2 Local Government Attention to the Digital Sector

The level of attention that local governments pay to the digital sector may lead to heterogeneous effects of state-owned capital participation on digital technology innovation in private enterprises. Specifically, the higher the local government's attention to the digital sector, the more likely it is to introduce policies supporting digital technology innovation (Tan et al., 2024), while simultaneously signalling to the outside world that private enterprises can expect greater government support and investor favour for engaging in digital technology innovation, which significantly strengthens their motivation to innovate. Moreover, in regions where local governments pay greater attention to the digital sector, state-owned capital is more motivated to support private enterprises' digital technology innovation in response to government initiatives. Based on this, it is inferred that the promoting effect of state-owned capital participation on digital technology innovation is more pronounced for private enterprises located in regions with higher local government attention to the digital sector. To test this inference, this study uses the frequency of keywords such as "digital economy," "cloud computing," and "communication technology" in municipal

government work reports as a proxy for local government attention to the digital sector; higher values indicate greater attention.

Furthermore, using the annual median of this variable as the cutoff, the sample is divided into two groups: regions with high government attention to the digital sector and regions with relatively low attention, to conduct heterogeneity tests. The regression results are shown in Columns (3) and (4) of Table 9. The results indicate that in the sample of private enterprises in regions with low government digital sector attention, the coefficient of State1 is not significant. In contrast, in regions with high government attention, it is significantly positive. This result suggests that, compared with private enterprises in regions with low government digital sector attention, the effect of state-owned capital participation in promoting digital technology innovation is more pronounced in enterprises located in regions with high government attention, consistent with the above inference.

7.3 Whether the Firm Belongs to the High-Tech Industry

Private enterprises in different industries face significant differences in market environments and competitive structures, which may lead to heterogeneous effects of state-owned capital participation on digital technology innovation. Specifically, compared with firms in high-tech industries, private enterprises in non-high-tech industries generally belong to traditional sectors, characterised by relatively stable market environments and high industry maturity. Consequently, private enterprises in non-high-tech industries tend to have lower motivation to engage in digital technology innovation. In contrast, high-tech industries experience rapidly changing market environments and intense competition, and the value of private enterprises in these sectors largely depends on cutting-edge technological innovation. Therefore, private enterprises in high-tech industries have more substantial incentives to innovate digitally and are more likely to allocate resources brought by state-owned capital to digital technology innovation projects. Based on this, it is inferred that the promoting effect of state-owned capital participation on digital technology innovation is more pronounced for private enterprises in high-tech industries. To test this inference, this study follows the 2012 industry classification standard of the China Securities Regulatory Commission (CSRC), defining firms with industry codes C25-C29, C31-C32, C34-C41, and I63-I65 as high-tech enterprises. Accordingly, the sample is divided into two groups: high-tech industries and non-high-tech industries, for heterogeneity tests. The regression results are presented in Columns (5) and (6) of Table 9. The results show that when the state-invested private enterprises belong to high-tech industries, the coefficient of State1 is significantly positive at the 1% level. In contrast, in non-high-tech industries, the coefficient of State1 is not significant, consistent with the above inference.

Table 9
Heterogeneity Test

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	with a bank-firm relationship	without a bank-firm relationship	high government attention	low government attention	high-tech industry	non-high-tech industry
	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>
<i>State1</i>	0.1288	1.1214***	0.9947**	0.2115	0.7179***	0.7598
	(0.6946)	(0.2840)	(0.4045)	(0.4056)	(0.2744)	(0.5188)
<i>Size</i>	0.4792***	0.3679***	0.2523***	0.4991***	0.3880***	0.4990***
	(0.0549)	(0.0271)	(0.0432)	(0.0290)	(0.0254)	(0.0522)
<i>Age</i>	-0.0476	0.1617***	0.1788***	0.1033***	0.1532***	0.1327**
	(0.0910)	(0.0280)	(0.0407)	(0.0396)	(0.0280)	(0.0534)
<i>Leverage</i>	0.0436	-0.1821*	0.0325	-0.2599**	-0.1346	-0.0526
	(0.2159)	(0.1064)	(0.1663)	(0.1219)	(0.1023)	(0.1942)
<i>ROA</i>	-0.0442	-0.2456	0.1652	-0.3887*	-0.1514	0.0401
	(0.3264)	(0.1855)	(0.2591)	(0.2223)	(0.1764)	(0.3357)
<i>Cashflow</i>	0.1200	-0.2458	-0.4069	0.0977	-0.2330	-0.1653
	(0.3193)	(0.1734)	(0.2620)	(0.2019)	(0.1670)	(0.3179)
<i>Growth</i>	-0.0667	-0.0350	-0.0446	-0.0430	-0.0398*	-0.0570
	(0.0488)	(0.0239)	(0.0340)	(0.0297)	(0.0233)	(0.0432)
<i>Board</i>	0.1883	0.1507*	0.1517	0.2224**	0.2231***	-0.0367
	(0.1757)	(0.0905)	(0.1417)	(0.1017)	(0.0857)	(0.1754)
<i>Top1</i>	0.0111***	-0.0004	-0.0006	0.0042**	0.0011	0.0052*
	(0.0035)	(0.0015)	(0.0021)	(0.0019)	(0.0015)	(0.0027)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Constant	-9.3985***	-6.6605***	-4.2745***	-9.7151***	-7.1244***	-10.0251***
	(1.2093)	(0.5828)	(0.9345)	(0.6316)	(0.5516)	(1.1237)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	with a bank-firm relationship	without a bank-firm relationship	high government attention	low government attention	high-tech industry	non-high-tech industry
	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>	<i>DTI</i>
N	2422	9795	6229	5988	9445	2772
R ²	0.8348	0.8143	0.8405	0.8329	0.7944	0.7135

8. Conclusion

Based on data from A-share listed private enterprises from 2013 to 2023, this study empirically examines the impact of state-owned capital participation on digital technology innovation from the perspective of resource dependence theory. The findings are as follows: (1) State-owned capital participation significantly promotes digital technology innovation in private enterprises, and this conclusion remains robust after a series of robustness checks. (2) Mechanism analysis indicates that state-owned capital participation facilitates digital technology innovation through two channels: alleviating financing constraints and curbing managerial myopia. (3) Supply chain stability plays a positive moderating role in the relationship between state-owned capital participation and digital technology innovation. That is, the stronger the supply chain stability, the more pronounced the innovation-promoting effect of state-owned capital. (4) Heterogeneity analysis shows that the innovation-promoting effect of state-owned capital participation is more pronounced in enterprises without bank-enterprise relationships, located in regions with high government attention to the digital sector, and operating in high-tech industries.

The theoretical contributions of this study are mainly reflected in two aspects. First, against the backdrop of the digital economy becoming a key pillar of national strategy, state-owned capital participation in the governance of private enterprises has become an important practice of mixed-ownership reform. Unlike previous studies that focus on the impact of state-owned capital participation on corporate financial performance or traditional innovation, this study, based on resource dependence theory, regards state-owned capital participation as a strategic response by private enterprises to actively cope with resource and uncertainty constraints in digital technology innovation. This perspective deepens and extends the application boundaries of resource dependence theory in the context of digital innovation and provides a new theoretical lens for understanding how mixed-ownership reform influences firms' micro-level innovation behaviours. Second, unlike most studies that discuss policy environment, corporate governance, or resource-based innovation drivers in isolation, this study innovatively integrates state-owned capital participation, managerial cognition, and external supply chain context into a unified analytical framework. It reveals two key mediating channels, alleviation of financing constraints and suppression of managerial myopia and identifies supply chain stability as an important boundary condition. This integrated framework not only enriches the literature on antecedents

of digital technology innovation in enterprises but also offers important theoretical insights and guidance for mechanism design to overcome the challenges of digital transformation in private enterprises from the perspectives of equity structure optimisation and internal-external resource integration.

Based on the findings and theoretical contributions of this study, the following policy implications are proposed from both the government and enterprise perspectives: For the government, it is essential to continue deepening mixed-ownership reform and to improve the institutional safeguards and implementation pathways for state-owned capital participation in private enterprises. Special attention should be given to private enterprises facing constrained financing channels, operating in non-high-tech sectors, or located in regions with weak digital infrastructure, by providing targeted capital and policy support to alleviate their innovation resource constraints effectively. At the same time, the dynamic optimisation of state-owned capital allocation should be emphasised. As market mechanisms improve and firms' independent innovation capabilities strengthen, the methods and intensity of capital participation should be adjusted appropriately to enhance resource allocation efficiency and long-term adaptability. For enterprises, they should proactively respond to policy guidance and actively introduce state-owned capital, leveraging its resource advantages and governance experience to overcome bottlenecks in digital innovation. Internally, enterprises need to establish a long-term, innovation-oriented governance mechanism by optimising performance evaluations, strengthening medium and long-term incentives, and improving supervision systems to curb managerial myopia effectively. Furthermore, attention should be paid to enhancing supply chain stability and collaborative innovation capabilities. Through digitalised management and long-term cooperation mechanisms, enterprises can strengthen supply chain resilience, thereby enabling state-owned capital participation to support digital innovation through effective resource integration more efficiently.

Declarations

Conflict of interest disclosure:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Statements

This article does not contain any studies with human participants performed by any of the authors

Funding:

This research was funded by the Professional Development Project for Visiting Scholars in Higher Education Institutions of the Provincial Department of Education "Research on the Impact Mechanism of

Media Emotions on the High Quality Development of Private Enterprises” (Grant No. FX2024183), amounting to USD 1,500; This research was funded by the Wenzhou Annual Regular Subjects of Philosophy and Social Science Planning (Grant No. 25WSK146YBM), amounting to USD 1,000.

Author Contribution

R.X. and X.C. designed the study and developed the methodology. F.H. collected and analyzed the data. L.X. prepared the figures and contributed to data visualization. R.X. and X.C. wrote the main manuscript text. All authors reviewed and approved the final manuscript.

Data Availability

The data that support the findings of this study are available upon reasonable request.

References

- Aghion, P., Bergeaud, A., Lequien, M., & Melitz, M. J. (2024). The heterogeneous impact of market size on innovation: Evidence from French firm-level exports. *Review of Economics and Statistics*, 106(3), 608-626.
- Bai, G., Zhao, J., & Xu, P. (2022). How do executives’ synergistic allocation and organizational slack drive enterprise technological innovation?. *Plos One*, 17(10), e0276022.
- Bai, M., Cai, J., & Qin, Y. (2021). Ownership discrimination and private firms financing in China. *Research in International Business and Finance*, 57, 101406.
- Balsmeier, B., Fleming, L., & Manso, G. (2017). Independent boards and innovation. *Journal of Financial Economics*, 123(3), 536-557.
- Berente, N., Gu, B., Recker, J., & Santhanam, R. (2021). Managing artificial intelligence. *MIS Quarterly*, 45(3), 1433-1450.
- Boardman, A. E., & Vining, A. R. (1989). Ownership and performance in competitive environments: A comparison of the performance of private, mixed, and state-owned enterprises. *The Journal of Law and Economics*, 32(1), 1-33.
- Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *The Journal of Finance*, 64(1), 151-185.
- Cao, X., Cumming, D., & Zhou, S. (2020). State ownership and corporate innovative efficiency. *Emerging Markets Review*, 44, 100699.

- Cen, T., & Lin, S. (2025). Digital transformation and corporate innovation in SMEs. *Systems*, 13(7), 551.
- Chen, H., & Rithmire, M. (2020). The rise of the investor state: State capital in the Chinese economy. *Studies in Comparative International Development*, 55(3), 257-277.
- Cheng, L., Cheng, H., & Zhuang, Z. (2019). Political connections, corporate innovation and entrepreneurship: Evidence from the China Employer-Employee Survey (CEES). *China Economic Review*, 54, 286-305.
- Dezsö, C. L., & Ross, D. G. (2012). Does female representation in top management improve firm performance? A panel data investigation. *Strategic Management Journal*, 33(9), 1072-1089.
- Ersahin, N., Giannetti, M., & Huang, R. (2024). Trade credit and the stability of supply chains. *Journal of Financial Economics*, 155, 103830.
- Li, F. S., Xu, Y. J., Du, P. C., et al. (2022). The impact of alliance management capabilities on enterprise disruptive technological innovation in the digital economy era. *Science & Technology Progress and Policy*, 39(4), 80-90.
- Gu, C., & Zhao, R. (2022). Does Signing Auditor's Reputational Promotion Ease the Financing Constraints of Audited Firms?. *Computational Intelligence and Neuroscience*, 2022(1), 3286181.
- Guan, J., Gao, Z., Tan, J., Sun, W., & Shi, F. (2021). Does the mixed ownership reform work? Influence of board chair on performance of state-owned enterprises. *Journal of Business Research*, 122, 51-59.
- Guellec, D., & Paunov, C. (2017). *Digital innovation and the distribution of income* (No. w23987). National Bureau of Economic Research.
- Hall, B. H., & Lerner, J. (2010). The financing of R&D and innovation. In *Handbook of the Economics of Innovation* (Vol. 1, pp. 609-639). North-Holland.
- Hao, D., & Qing, Y. (2025). Can Supply Chain Stability Achieve Stable Employment?. *Journal of Finance and Economics*, 51(02), 123-137.
- He, Z. L., Tong, T. W., Zhang, Y., & He, W. (2018). Constructing a Chinese patent database of listed firms in China: Descriptions, lessons, and insights. *Journal of Economics & Management Strategy*, 27(3), 579-606.
- Hillman, A. J., Withers, M. C., & Collins, B. J. (2009). Resource dependence theory: A review. *Journal of Management*, 35(6), 1404-1427.
- Hu, S., Zhou, X., & Li, P. (2025). Tax incentives, market competition, and corporate innovation. *Finance Research Letters*, 77, 107067.

- Jin, X., Yu, J., Yuan, G., & Zang, R. (2025). Impact of State-Owned Equity Participation on the Risk-Taking Capacity of Private Enterprises in China: Insights From a Quasinatural Experiment. *Corporate Governance: An International Review*, 33(4), 629-662.
- Kang, J. K., Luo, J., & Na, H. S. (2018). Are institutional investors with multiple blockholdings effective monitors?. *Journal of Financial Economics*, 128(3), 576-602.
- Kaplan, S. N., & Zingales, L. (1997). Do investment-cash flow sensitivities provide useful measures of financing constraints?. *The Quarterly Journal of Economics*, 112(1), 169-215.
- Kroll, H., & Kou, K. (2019). Innovation output and state ownership: Empirical evidence from China's listed firms. *Industry and Innovation*, 26(2), 176-198.
- Leutert, W. (2016). Challenges ahead in China's reform of state-owned enterprises. *Asia Policy*, 21(1), 83-99.
- Lyytinen, K., Yoo, Y., & Boland Jr, R. J. (2016). Digital product innovation within four classes of innovation networks. *Information Systems Journal*, 26(1), 47-75.
- McIntyre, D. P., & Srinivasan, A. (2017). Networks, platforms, and strategy: Emerging views and next steps. *Strategic Management Journal*, 38(1), 141-160.
- Minetti, R., Murro, P., Rotondi, Z., & Zhu, S. C. (2019). Financial constraints, firms' supply chains, and internationalization. *Journal of the European Economic Association*, 17(2), 327-375.
- Palmon, D., & Yezegel, A. (2012). R&D intensity and the value of analysts' recommendations. *Contemporary Accounting Research*, 29(2), 621-654.
- Pfeffer, J., & Salancik, G. (2015). External control of organizations—Resource dependence perspective. In *Organizational behavior 2* (pp. 355-370). Routledge.
- Soni, U., Jain, V., & Kumar, S. (2014). Measuring supply chain resilience using a deterministic modeling approach. *Computers & Industrial Engineering*, 74, 11-25.
- Svahn, F., Mathiassen, L., & Lindgren, R. (2017). Embracing digital innovation in incumbent firms. *MIS Quarterly*, 41(1), 239-254.
- Tumbas, S., Berente, N., & Brocke, J. V. (2018). Digital innovation and institutional entrepreneurship: Chief Digital Officer perspectives of their emerging role. *Journal of Information Technology*, 33(3), 188-202.
- Wan, K., & Yu, X. (2022). Impact of mixed ownership reforms on firm innovation—empirical evidence from China. *Journal of Applied Economics*, 25(1), 1339-1354.
- Wang, X., Li, Y., Tian, L., & Hou, Y. (2023). Government digital initiatives and firm digital innovation: Evidence from China. *Technovation*, 119, 102545.

- Wang, X., Zhao, J., Zhang, H., & Tang, X. (2022). The Impact of the Scale of Third-Party Logistics Guaranteeing Firms on Bank Credit Willingness in Supply Chain Finance: An ERP Study. *Frontiers in Psychology, 13*, 853888.
- Wang, Y., Abbasi, K., Babajide, B., & Yekini, K. C. (2020). Corporate governance mechanisms and firm performance: evidence from the emerging market following the revised CG code. *Corporate Governance: The International Journal of Business in Society, 20*(1), 158-174.
- Wehrheim, D., Dalay, H. D., Fosfuri, A., & Helmers, C. (2020). How mixed ownership affects decision making in turbulent times: Evidence from the digital revolution in telecommunications. *Journal of Corporate Finance, 64*, 101626.
- Wei, F., & Zhou, L. (2024). Do state-owned enterprises prefer capital from private enterprises with better ESG performance? Evidence from China's mixed ownership reforms. *Finance Research Letters, 62*, 105067.
- Tan, W. J., Liu, Y. Q., & Shen, M. H. (2024). "Supporting Hand": Government Digital Procurement and Enterprise Digital Technology Innovation. *Journal of Shanghai University of Finance and Economics, 26*(03), 18-32.
- Wen, J., & Deng, Y. (2023). How does intellectual property protection contribute to the digital transformation of enterprises?. *Finance Research Letters, 58*, 104340.
- Xiao, Z., Niu, Q., Yun, F., & Ye, Y. (2024). The impact of state-owned capital on labor cost stickiness in private firms: Evidence from China. *Economic Modelling, 141*, 106906.
- Xu, K., Tihanyi, L., & Hitt, M. A. (2017). Firm resources, governmental power, and privatization. *Journal of Management, 43*(4), 998-1024.
- Xu, S., Chen, S., Jiao, W., & Chen, M. (2025). State-owned enterprises shareholders and innovation of private enterprises: Evidence from China. *Technovation, 140*, 103144.
- Yan, H., Chen, Z., & Yang, Y. (2024). State-owned capital and quality of green innovation: Evidence from Chinese listed private firms. *Heliyon, 10*(7).
- Zhai, S. B., Yi, H. Q., Zheng, J., Tang, W., & Cao, X. Q. (2014). Bank-Enterprise Relationship and Corporate Investment Efficiency: Based on Empirical Evidence of Private Listed Companies in China. *Accounting Research, 4*, 74-80.
- Zhan, J., & Zhu, J. (2021). The effects of state ownership on innovation: evidence from the state-owned enterprises reform in China. *Applied Economics, 53*(1), 145-163.
- Zhan, S. (2023). Ultimate control rights, nationalization and firm performance: evidence from China. *Emerging Markets Finance and Trade, 59*(12), 3731-3740.

Zhang, X., Yu, M., & Chen, G. (2020). Does mixed-ownership reform improve SOEs' innovation? Evidence from state ownership. *China Economic Review*, 61, 101450.

Footnotes

1. According to the Company Law, shareholders who individually or cumulatively hold more than 10% of a company's shares are entitled to request a shareholders' meeting. Therefore, this study adopts 10% as the threshold for determining the presence of a major state-owned shareholder.
2. <https://finance.sina.com.cn/tech/2021-07-16/doc-ikqcfnc7242385.shtml>.