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Research article

Identification of the enterprise financialization motivation on crowding out R&D innovation: evidence from listed companies in China

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Abstract: Enterprise financial asset allocation depends on its motivation, which significantly influences its R&D innovation. In this study, we theoretically analyzed the motivation behind the crowding-out effect of enterprise financialization on R&D innovation and constructed a panel data model to identify enterprise financialization behavior. Furthermore, we analyzed the characteristics of enterprises with two types of effects on R&D innovation: Crowding-out and non-crowding-out. Using disclosed data from listed companies in China as the sample, the following conclusions were drawn. First, there are two types of motivation for enterprise financial assets: reservoir motivation and substitute motivation. This difference in motivation leads to whether there is a crowding-out effect of enterprise financialization on R&D innovation. Second, based on whether there is a crowding-out effect on enterprise R&D innovation, we found that the difference in reservoir motivation between the two types of samples is reflected in the intensity of inhibition, while the difference in substitute motivation is reflected in significance. Third, there are differences in the mechanism variables of financialization motivation among different samples. The moderating effect of equity concentration is reflected in its intensity, while the moderating effect of financing constraints is reflected in its significance.

Keywords: panel data model; financialization motivation; R&D innovation; crowding-out effect
Mathematics Subject Classification: 91B80

1. Introduction

Enterprise financialization not only exacerbates the problem of 'shifting from real to virtual' but also undermines the R&D innovation capabilities of enterprises. The growth rate of the real economy has been continuously declining under the influence of factors such as the COVID-19 pandemic, leading to sustained decreases in its profitability and a sluggish state of global real economic development. As micro-subjects of economic development, enterprises should increase R&D investments and enhance technological innovation capabilities to fundamentally promote the development of the real economy. However, due to the significant amount of funding required for corporate R&D innovation, long R&D cycles, high uncertainty, and other high-risk characteristics, the short-term economic effects brought about by corporate innovation are not apparent. As corporate behavior increasingly leans towards financial investment, industrial capital is more allocated to the financial sector, consequently reducing investments in R&D innovation and hindering the progress of corporate R&D innovation activities. Moreover, corporate operational profits increasingly depend on financial channels, causing a change in investment preferences and reducing the emphasis on R&D innovation, thereby weakening corporate R&D innovation capabilities. In existing research on the influence of financialization behavior on corporate R&D innovation, scholars have primarily proposed two viewpoints: positive and negative effects.

Financialization behavior has a promoting effect on corporate R&D innovation. Due to the severe financing constraints and the need for stable financial support for innovation activities, firms primarily rely on internal financing for R&D innovation [1–3]. From a liquidity perspective, non-financial corporations should hold financial assets. Empirical studies have shown that financially constrained firms should increase their holdings of liquid assets when experiencing high cash flows [4]. Compared to fixed assets, financial assets have higher liquidity and lower adjustment costs, effectively alleviating financing constraints when firms face funding shortages [5–7]. Some literature focuses on the motivations behind enterprise financialization behavior, suggesting that the 'reservoir' motive is the main driver behind corporate financial asset allocation [8,9]. Research by Yarba and Yassa [10] suggests that the stock investment behavior of listed companies in China is based on the motivation of cash management and profit smoothing rather than investment motives. Gao, Wang [11] found a significant negative correlation between corporate financial asset allocation and GDP cycle variables, a positive correlation with broad money M2 cycle variables and statutory reserve ratio, and a significant negative correlation with stock index growth rate, indicating that the primary purpose of corporate financial asset allocation is for precautionary reserves. Additionally, some scholars argue that enterprise financialization behavior can diversify corporate financing channels [12,13]. The high profits obtained from financial channels can timely alleviate corporate financing constraints, providing support for R&D innovation activities [14,15]. Brown and Petersen [16] suggest that as the cost of adjusting R&D flow due to short-term financing shocks is extremely high, firms facing financial friction generally rely on cash reserves to smooth R&D innovation expenditures. Research by Liu et al. [17] indicates that the share of financial asset holdings is more similar to 'precautionary savings' behavior for R&D innovation. An increase in the share of financial asset holdings helps promote future corporate R&D innovation, which is particularly evident in private enterprises. Therefore, holding financial assets benefits the continuity of R&D innovation. Duan et al. [18] found that when studying the motives behind corporate trading financial asset allocation, enterprises actively adjust the proportion of financial asset allocation to adapt to changes in monetary policy. Tradable financial assets

help alleviate under-investment in private enterprises and maintain sustained investment in corporate R&D innovation [19,20]. Xu et al. [21], based on high-tech enterprises listed on China's Shenzhen Stock Exchange's SME Board, found that due to existing constraints on R&D financing and rigid demand for R&D investment, high-tech SMEs primarily allocate financial assets with the 'reservoir' motive. The higher the financialization level of high-tech SMEs, the more they invest in R&D innovation [22,23]. This promotion effect is more pronounced in high-tech SMEs with private property rights and lower levels of financial development in the region [24].

Financialization behaviors have a dampening effect on corporate R&D innovation. As enterprise financialization continues to deepen, more research focuses on the crowding-out effects of financialization on corporate R&D innovation. From an investment substitution perspective, there exists a substitution relationship between corporate allocation of financial assets and R&D innovation. Financial asset investment and corporate operational investments can be seen as an investment portfolio. When operating profit margins decline, companies tend to scale back operational investments and increase investments in financial assets [25,26]. In situations of limited resources, the relationship between enterprise financialization and R&D innovation investment is one of the 'trade-offs'. As companies allocate more financial assets, there is a corresponding reduction in the scale of funds invested in R&D innovation [27]. Lazonick and Teece [28], employing data from non-financial companies in the United States, found that financialization phenomena are widespread in the American real economy. Enterprise financialization leads to the compression of core business investments, thereby squeezing expenditures on R&D innovation and diminishing the ability for independent innovation. Xie et al. [29] argue that excessive financialization alters a company's production mode, shifting the focus of corporate production and weakening the foundation for technological innovation. Additionally, the process of capital accumulation where 'money begets money' induces industrial capital to transform into financial capital [30–32]. Moreover, excessive financialization leads to short-termism in corporate governance, weakening incentives for technological innovation and thereby curbing the capacity for R&D innovation. From an arbitrage speculation perspective, excessive allocation of financial assets by companies is for the sake of pursuing pure capital appreciation to maximize shareholder interests rather than to reserve funds for production and operation. This short-term profit-driven behavior changes the company's investment preferences, ultimately crowding out the company's R&D innovation activities. Kim et al. [33], studying non-financial companies in South Korea from 1994 to 2009, found that companies, in pursuit of high returns, increase investments in financial assets, investing in stocks with high returns, which, over the long term, squeezes investment in R&D innovation activities. Liu et al. [17], focusing on non-financial enterprises in China, found that financialization behavior alters a company's profit model. When a company's profit model relies more on investment in financial assets, it not only squeezes current R&D innovation activities but also inhibits future R&D innovation activities. Huang et al. [34] argue that companies investing in financial assets for high-profit returns engage in market arbitrage. The financialization of physical enterprises squeezes R&D innovation, and the stronger the speculative motive, the stronger the crowding-out effect. Conversely, companies with stronger profit-making abilities, due to fewer arbitrage opportunities and higher costs associated with such opportunities, experience a weaker crowding-out effect of financialization on corporate innovation. Zhang et al. [35], using data from Chinese manufacturing companies listed on the stock market, found that the impact of financialization on corporate innovation investment is influenced by the company's operational performance. When the company's operational performance is poor, the motive for short-term arbitrage gains through financial

investment becomes stronger, leading to a stronger crowding-out effect of speculative arbitrage-motivated financialization behavior on corporate R&D innovation investment. Furthermore, research has examined the inhibitory effects of financialization behavior on corporate R&D innovation from various perspectives, such as companies holding different types of financial assets [36], different industries [37], and are at different life-cycle stages.

From the perspective of the inhibitory effect of financialization on R&D innovation, its essence is the crowding out effect of financialization on R&D innovation. The main reason for the crowding out effect in enterprises is substitution motivation. According to the principal-agent mechanism, the goal of an agent is to maximize their own interests. In the process of financial asset allocation, the interests of agents are more short-term, so agents are more willing to invest funds in financial fields that can achieve higher returns in the near future, thereby crowding out investment in R&D innovation, resulting in crowding out effects.

Our marginal contribution includes two aspects: First, this study is an identification study of the motivation behind financialization behavior's crowding-out effect on R&D innovation. Existing research shows that companies allocate financial assets based on two motivations: 'reservoir' and 'substitution'. The behavior of allocating financial assets in different scenarios leads to different effects on corporate R&D innovation. Based on this, we identified the motives behind the crowding-out effect through empirical testing. Secondly, this study examines the crowding-out effect characteristics of different sample categories. Based on the identification of whether a crowding-out effect exists, the entire sample is categorized into those with and without crowding-out effects, and their characteristics are compared to gain deeper insights into enterprise financialization behavior.

The remaining structure of this paper is organized as follows: the second part presents the research methodology, the third part conducts empirical analysis on the crowding-out effect of financialization on R&D innovation, the fourth part compares the characteristics of samples with and without crowding-out effects, and the fifth part presents the conclusion of this paper.

2. Materials and methods

2.1. Construction of the motivation identification model

Enterprise financialization behavior constitutes an organizational behavior within the decision-making process of principals. Despite the distinction between two motivations in the process of corporate asset allocation, namely, "reservoir (serving the preventive function of providing liquidity to enterprises)" and "substitute (enterprises opt for asset categories based on asset value)", from a behavioral perspective, both motivations are decisions made by enterprises to mitigate risks. The mechanism behind risk behavior emanates from two aspects: First, the elevation in the level of financialization weakens the enterprise's capacity to bear risks. Non-financial enterprises operate predominantly in the real economy domain, involving mostly physical assets. They possess ample experience in the operation of physical assets (such as production, supply, sales, and quantity-based interest). However, their experience is relatively limited concerning the optimization of financial asset allocation, risk identification, and risk management and control. According to the principle of risk-return parity, enterprises undertaking asset allocation for higher profits must accept higher risks. For instance, if an enterprise incurs losses in financial asset investments and fails to recuperate them, it will significantly impact the enterprise's cash flow and inevitably exert a substantial negative influence

on productive investment activities. This leads to a drastic decline in the enterprise's risk-bearing capacity, potentially triggering bankruptcy risks. With an increase in the level of enterprise financialization, the scale of financial asset allocation by enterprises expands, leading to reduced funds available for strategic investments in production areas and R&D innovation. Consequently, when enterprises need to invest in R&D innovation, they can rely only on collateralizing relevant assets. After asset collateralization, the enterprise's debt repayment capability and fundraising capacity both significantly decrease, while external financing capabilities also diminish, thereby weakening the enterprise's ability to bear risks.

On the other hand, the risk contagion effect also diminishes the enterprise's resilience to risk. During the process of corporate financial asset allocation, specific financial assets are involved. For example, enterprises often allocate financial assets to real estate or financial derivative products. The real estate sector possesses high risks and is significantly impacted by macroeconomic regulation. Particularly during real estate bubble crises when property prices plummet, if enterprises allocate assets to the real estate sector, the risks inherent in real estate will, through a "risk contagion effect", pose risks to enterprises, exacerbating both financial and operational risks. When enterprises allocate financial assets to derive product sectors due to factors such as information technology and online public opinion, the interdependence between the financial system and non-financial corporate sectors intensifies. Therefore, risks stemming from changes in the external market environment, policy fluctuations, and other aspects are transmitted to non-financial enterprises. Moreover, enterprises often finance R&D investments through capitalized income methods to avoid compounding risks with their core business. As a result, they often choose to delay investment in R&D innovation activities to reduce the enterprise's risk level, essentially reducing the enterprise's risk-bearing capacity.

Based on the aforementioned theoretical analysis and under the assumption of risk aversion, through quantitative methods, we identified motivations within enterprise financialization behavior and investigated the relationship between reservoir motivation, substitute motivation, and the crowding-out impact on R&D innovation. Given the characteristics of the data type, we utilized a panel fixed-effects model to analyze and identify the impacts of reservoir and substitute motivations within financialization behavior on the crowding-out effect concerning R&D innovation. The basic form of the model is illustrated in Eq (1).

$$\mathrm{Coe}_{it} = \alpha_0 + \alpha_1 \mathrm{Xsc}_{it} + \alpha_2 \mathrm{Td}_{it} + \sum_j^N \beta_j \mathrm{CV}_{ijt} + \rho_g + \tau_s + \gamma_t + \mu_{it}. \quad (1)$$

Based on Model (1), incorporate the quadratic term of the reservoir motive (Xsc) and the quadratic term of the substitution motive (Td) to obtain Model (2), aiming to further examine the nonlinear effects of the reservoir and substitution motives within financialization behavior on the crowd-out of research and development innovation.

$$\mathrm{Coe}_{it} = \alpha_0 + \alpha_1 \mathrm{Xsc}_{it} + \alpha_2 \mathrm{Xsc2}_{it} + \alpha_3 \mathrm{Td}_{it} + \alpha_4 \mathrm{Td2}_{it} + \sum_j^N \beta_j \mathrm{CV}_{ijt} + \rho_g + \tau_s + \gamma_t + \mu_{it}. \quad (2)$$

In Eqs (1) and (2), Coe_{it} denotes the crowding-out value of the R&D innovation for the ith listed company in year t[1]; Xsc_{it} represents the reservoir motive of financialization for the ith listed company

[1] To measure the extent of financialization impact on the crowding-out effect of R&D innovation in enterprises, we followed these core procedures based on existing research: First, selecting samples with moderate-level financialization from the study subjects. Second, utilizing these moderate-level samples, compute the standard values of R&D innovation by industry. Third, using the standard values as reference points, compute the difference between the R&D innovation values of the companies under study and the standard values; this difference represents the degree of R&D innovation crowding-out in this paper. Relevant literature sources for defining moderate standards are referenced from the Electronic Research Archive paper (2022).

in year t; $Xsc2_{it}$ indicates the quadratic term of the reservoir motive in financialization for the ith listed company in year t, calculated by $Xsc2_{it} = Xsc_{it} * Xsc_{it}$; Td_{it} denotes the substitution motive of financialization for the ith listed company in year t; $Td2_{it}$ represents the quadratic term of the substitution motive in financialization for the ith listed company in year t, calculated through $Td2_{it} = Td_{it} * Td_{it}$; CV_{ijt} signifies the jth control variable for the ith listed company in year t; where coefficient $\alpha_1 - \alpha_4$ is the key parameter of interest, that is the impact of different financialization motives on the crowding-out effect of R&D innovation in companies. Furthermore, ρ_g stands for industry fixed effects; τ_s stands for individual fixed effects; γ_t represents time effects; α_0 denotes the constant term, and μ_{it} represents the error term.

Given the substantial number and heterogeneity of listed companies, besides introducing individual firm effects, this section incorporates industry dummy variables to control for individual firm effects by industry division. Additionally, considering the temporal trend in crowding out R&D innovation among listed companies, the model includes time dummy variables to account for time trend effects.

2.2. Variable measurement and data description

The model specification involves two core explanatory variables. One explanatory variable is the reservoir motivation (Xsc) within enterprise financialization behavior. Enterprises, driven by sustainable development strategies, ensure liquidity and profitability by allocating corresponding financial assets, thus averting potential future financing constraints. This effectively reduces the dependency of technological innovation on external financing [38], achieving the reservoir effect of financial assets. Moreover, it aids in improving capital utilization efficiency and increasing enterprise investment in R&D innovation. Considering enterprise motivations for financialization and the research objectives, when enterprises possess long-term strategic investment needs and aim to prevent liquidity problems, they tend to allocate financial assets primarily towards R&D innovation expenditures. Considering the non-independence between R&D innovation intensity and financialization, we measured reservoir motivation using the product (i.e., interaction effect) of R&D innovation intensity and the degree of financialization. R&D innovation intensity is measured by the ratio of intangible assets to total assets, while the degree of financialization is measured by the ratio of financial assets to total assets.

The other explanatory variable is the substitute motivation within enterprise financialization behavior. Some academic studies also term substitute motivation as speculative arbitrage motivation, mainly referring to the substitution relationship between financial assets and R&D innovation. Allocating more financial assets under substitute motivation implies a reduction in enterprise R&D innovation [17,28,29]. Enterprises allocate more financial assets under substitute motivation to gain excessive returns. However, this excessive allocation of financial assets tends to hinder investment in R&D innovation activities, resulting in the crowding-out effect of R&D innovation caused by enterprise financialization [35]. When enterprises exhibit substitute motivation, a significant portion of their profits originates from financial asset returns. Additionally, financial asset returns interact with the level of financialization. Therefore, the substitute motivation within enterprise financialization behavior is measured using the product of the ratio of financial asset returns and the degree of financialization. The ratio of financial asset returns is determined by referencing other literature [17,39], using the sum of fair value changes, investment returns, and other comprehensive income divided by total profits, represented as (fair value changes+investment returns+other comprehensive income)/total

profits.

To control for other enterprise-specific characteristics influencing the crowding-out effect of R&D innovation, relevant variables are included in the empirical process. Considering characteristics of listed companies and factors influencing enterprise R&D innovation crowding out, we selected six control variables: Equity Concentration (Shrcr), Financing Constraints (SA), Cash Flow of Operation (Cfo), Enterprise Capital Intensity (Fixed), Enterprise Operating Net Profit Margin (Roa), and Corporate Capital Structure (Lev). The reasons for selecting the six control variables are as follows: The concentration of equity is the proportion of shares held by the top ten shareholders, and the higher the concentration, the more inclined corporate governance is towards concentration. In terms of financial asset allocation, it will lean towards the interests of major shareholders and ignore the interests of the minority. Financing constraints prohibit R&D innovation expenditures, and there is a significant difference in the payback period between enterprise R&D investment and other investments. Therefore, decision-makers consider short-term benefits more when making decisions. Cash flow reflects the normal situation of a company in its operating process and has a strong sensitivity to the allocation of financial assets. The capital intensity of a company is strongly related to its products. The higher the technological content of the product, the more inclined the company is to invest in research and development, as this is beneficial to the long-term interests of the company. The net profit margin of enterprise operation reflects the net profit situation of the enterprise, and its net profit situation is the main reference basis for the next investment decision, which will have a significant impact on the allocation of financial assets. The capital structure of a company also constrains its investment behavior, as different capital structures result in significant differences in the various risks faced by enterprises.

Based on this, the summary of relevant variables and their measurement methods involved in Eqs (1) and (2) is presented in Table 1.

The temporal scope of the data in this study spans from 2010 to 2019, encompassing a data set of 1,221 non-financial listed companies in China. The data for variables utilized in this research are sourced from the China Securities Market & Accounting Research (CSMAR) database. Descriptive statistics for the relevant variables are presented in Table 2.

Table 2 reports the basic statistical characteristics of the variable data from 1,221 non-financial listed companies between 2010 and 2019. From Table 2, it is observed that the dependent variable Coe, representing enterprise R&D innovation crowding-out level, ranges from a minimum of -0.1290 to a maximum of 0.7187, with a mean of -0.0050, indicating the presence of financialization effects on R&D innovation across various types of companies. Looking at the statistical features of the reservoir motive Xsc within enterprise financialization, its mean value is 0.0041, ranging from a minimum of 0.0000 to a maximum of 0.1384, suggesting that the average intensity of the reservoir motive in enterprise financialization is not high, with relatively minor differences across companies. Examining the statistical features of the substitution motive Td within enterprise financialization, its mean value is 0.0296, with a minimum of -766.1393 and a maximum of 137.2656, indicating substantial variability and potential outliers within the substitution motive data. Overall, there appears to be significant heterogeneity within the substitution motive across enterprise financialization behavior.

Table 1. Variable descriptions.

Variable type	Variable	Abbreviation	Measurement
Dependent variable	R&D innovation crowding out	Coe	Company's R&D Innovation Minus R&D Innovation Benchmark Value
Explanatory variables	Reservoir motive	Xsc	The product of R&D intensity and the degree of financialization
	Substitution motive	Td	The product of the financial asset return ratio and the degree of financialization, where the financial asset return ratio=(Fair Value Changes+Investment Income+Other Comprehensive Income)/Total Profits
Control variables	Equity concentration	Shrcr	Sum of the shareholding proportions of the top ten shareholders
	Financial constraint	SA	SA=0.043 * Size * Size - 0.737 * Size - 0.04 * Age, where Size=ln(Total Assets/1,000,000) and Age denotes the years since establishment
	Cash flow of operation	Cfo	Net cash flow generated from operating activities divided by total assets at the end of the period
	Capital intensity	Fixed	Ratio of end-of-period fixed assets to total assets
	Net profit margin	Roa	Net profit divided by total assets at the end of the period
	Capital structure	Lev	Ratio of total liabilities to total assets at the end of the period

Table 2. Descriptive statistics of variables.

VarName	Obs	Mean	SD	Min	Max
Coe	12210	-0.0050	0.064	-0.1290	0.7187
Xsc	12210	0.0041	0.008	0.0000	0.1384
Td	12210	0.0296	7.166	-766.1393	137.2656
Shrcr	12210	56.1158	15.689	11.1900	100.0100
SA	12210	-3.8116	0.276	-5.7933	-2.1126
Cfo	12210	0.0454	0.072	-0.5655	0.5526
Fixed	12210	0.2201	0.174	0.0002	0.9709
Roa	12210	0.0364	0.106	-7.7001	0.4690
Lev	12210	0.4634	0.215	0.0071	5.6808

3. Empirical results of motive identification

3.1. Parameter estimation results

Multiple experiments suggest that different motives behind enterprise financialization behavior lead to varying impacts on R&D innovation at different levels of financialization. Initial findings demonstrate a significant effect of enterprise financialization behavior driven by the reservoir motive on crowding out R&D innovation, whereas the effect of enterprise financialization behavior driven by the substitution motive appears to be insignificant. Accordingly, we employed two types of models in the model setup: a general linear panel data model (Eq (1)) and a nonlinear panel data model (Eq (2)). By utilizing the aforementioned sample data, parameter estimation was conducted to identify the motives behind enterprise financialization. The results of parameter estimation are presented in Table 3. Columns (1) and (2) list the parameter estimation results of linear panel data in financialization behavior, where Column (1) is the fixed-effect model controlling the industry, denoted as IFE1 (1),

and Column (2) is the fixed-effect model controlling the individual, denoted as IFE2 (2). Columns (3) and (4) show the parameter estimation results of the nonlinear panel data model after the quadratic terms of two different motivations are added. Column (3) is the fixed effect model controlling the industry, denoted as IFE1 (3), and Column (4) is the fixed effect model controlling individuals, denoted as IFE2 (4).

Table 3. Empirical regression results of financialization motive identification.

	IFE1 (1)	IFE2 (2)	IFE1 (3)	IFE2 (4)
	Coe	Coe	Coe	Coe
Xsc	4.0779***	2.4832***	4.9385***	3.5126***
	(23.5175)	(48.3578)	(22.1296)	(41.0309)
Xsc2			-17.0095***	-18.9038***
			(-3.5496)	(-14.8520)
Td	-0.0000	-0.0000	-0.0012***	-0.0001
	(-0.4703)	(-0.1182)	(-2.8390)	(-0.9495)
Td2			-0.0000***	-0.0000
			(-2.9696)	(-1.0476)
Shrcr	0.0002***	0.0001*	0.0002***	0.0001***
	(4.9134)	(1.7287)	(5.5200)	(2.8232)
SA	-0.0072***	0.0011	-0.0072***	0.0026
	(-3.5664)	(0.2201)	(-3.6215)	(0.5277)
Cfo	0.0502***	0.0093**	0.0484***	0.0095**
	(7.0308)	(2.2784)	(6.8430)	(2.3609)
Fixed	-0.0222***	0.0213***	-0.0211***	0.0208***
	(-3.7796)	(6.0083)	(-3.6538)	(5.9276)
Roa	0.0036	0.0049	0.0045	0.0065**
	(0.3327)	(1.6022)	(0.4179)	(2.1305)
Lev	0.0302***	0.0162***	0.0319***	0.0181***
	(10.4286)	(6.0910)	(10.8683)	(6.8462)
Industry Fixed Effects	YES	NO	YES	NO
Individual Fixed Effects	NO	YES	NO	YES
Time Effects	YES	YES	YES	YES
_cons	-0.0877***	-0.0024	-0.0949***	-0.0020
	(-9.0226)	(-0.1319)	(-9.6417)	(-0.1081)
N	12210	12210	12210	12210

Note: t statistics are in parentheses: *p<0.1, **p<0.05, ***p<0.01.

Using Table 3, we analyzed the two types of motives behind enterprise financialization behavior. Table 3 illustrates that when enterprise financialization is driven by reservoir motivation, an inverted U-shaped relationship exists between the level of enterprise financialization and the R&D innovation crowding-out level. As seen in Columns IFE1 (1) and IFE2 (2) in Table 3, irrespective of individual or industry-fixed effects, the regression coefficient of the reservoir motivation explanatory variable's

linear term is positive and statistically significant at the 1% level. This suggests that when enterprise financialization behavior is motivated by reservoir intentions, it significantly mitigates the crowding-out impact of financialization on R&D innovation. Additionally, the inhibitory effect of reservoir motivation at the industry level is stronger compared to the individual level. In Columns IFE1 (3) and IFE2 (4) of Table 3, it is observed that the quadratic term regression coefficient of reservoir motivation is significantly negative when enterprise financialization is driven by reservoir intentions. Combined with the linear term analysis, this indicates a non-linear inverted U-shaped relationship between enterprise financialization level and R&D innovation crowding-out level. Initially, an increase in enterprise financialization due to reservoir motivation suppresses the rise in R&D innovation crowding-out level. However, after a turning point, an elevation in enterprise financialization due to reservoir motivation intensifies the crowding-out effect on R&D innovation. Furthermore, differences exist in the impact of enterprise financialization level on R&D innovation crowding out concerning industry and individual control effects.

The reasons for these results can be explained from two perspectives. Initially, during the early stages of enterprise financialization, due to the higher liquidity of financial assets compared to fixed assets, enterprises, aiming to address future uncertainties, alleviate cash flow fluctuations, and mitigate external financing constraints, and consider allocating more financial assets to achieve a 'reservoir' effect. These highly liquid financial assets effectively reduce adjustment costs for enterprises, smoothing out tangible investments and innovative R&D activities [17,40] and facilitating a steady investment in R&D innovation that fosters sustainable enterprise development [40,41]. Thus, it is evident that during the initial phase, when the reservoir motivation-driven financialization behavior is on the left side of the inverted 'U' curve, it doesn’t crowd out R&D innovation investments. On the contrary, it promotes investments in R&D innovation funds, thus strengthening the enterprise's competitiveness and sustainability through innovation.

Conversely, as enterprise financialization levels continue to rise, reservoir-driven financialization behavior not only reduces investment risks and adjustment costs but also generates short-term gains for enterprises. However, R&D innovation activities are long-term investments whose returns are challenging to surpass in the short term compared to financial asset returns [5]. Given the uncertainty of R&D innovation and the profit-seeking nature of capital, agents tend to gradually allocate the profits generated by reservoir-driven financialization behavior into more financial assets, reducing ongoing investments in R&D innovation. At this point, the financialization behavior driven by reservoir motives is situated on the right side of the U-shaped curve, leading to the continued allocation of funds into financial assets, thereby reducing relative investments in R&D, consequently intensifying the crowding-out effect of reservoir-driven financialization behavior on R&D innovation.

According to Table 3, the relationship between the level of enterprise financialization due to substitution motives and R&D innovation is not significant. As observed in Columns IFE1 (1) and IFE2 (2), the coefficient of the first-order regression for substitution motives is negative; yet, it fails to achieve statistical significance at the 10% level. This indicates that the linear impact of enterprise financialization driven by substitution motives on the R&D innovation crowding-out level is not significant. We examined the parameter estimations of the first-order and second-order “U-shaped” relationship between financialization behavior driven by substitution motives and the R&D innovation crowding-out level. However, under individual fixed effects, the influence of enterprise financialization driven by substitution motives on the R&D innovation crowding-out level is not significant. Therefore, further robustness tests are required to confirm the impact of financialization

behavior driven by substitution motives on crowding out R&D innovation. Moreover, this insignificance in the relationship is highly associated with the substantial heterogeneity in enterprise behavior driven by substitution motives.

For the substitution motive, the level of enterprise financialization is not significantly related to R&D innovation mainly due to the following two reasons. One is the sensitivity of the substitution motive. The substitution motivation is that stakeholders make decisions from the perspective of profit maximization. In the context of the market economy and information economy, the conditions of profit maximization change very quickly. Decision-making out of the substitution motive for financial asset allocation needs to be changed at any time, but other conditions change with a lag of different periods. The other reason is that industries and individuals are heterogeneous, and although we control for some individual and industry factors in model parameter estimation, the interaction effect between individuals and industries cannot be completely eliminated, which makes the significance decrease.

Finally, considering the magnitude and significance of the estimated coefficients for financialization behavior driven by both motives, the impact of financialization behavior driven by the reservoir motive on crowding out R&D innovation appears to be greater than that of the substitution motive. This implies that during the R&D innovation process, financialization behavior primarily centers on the reservoir motive initially. Financialization behavior driven by the reservoir motive effectively enhances R&D innovation investment and suppresses the innovation crowding-out effect. However, after reaching a turning point, the short-term profit incentives of financialization behavior driven by the reservoir motive might strengthen the crowding out of R&D innovation, gradually shifting the asset allocation process of enterprises towards substitution motives.

3.2 Robustness tests of estimation results

In order to substantiate the robustness of the conclusions in this subsection and mitigate potential endogeneity issues among variables, we utilized various estimation methods such as the Two-Stage Least Squares (2SLS), the System Generalized Method of Moments (GMM), and the Difference GMM to estimate the parameters in the baseline Models (1) and (2). This was done to analyze the robustness of the relationship between enterprise financialization behavior driven by reservoir and substitution motives and the crowding-out effect on R&D innovation. The parameter estimates derived from the sample data are presented in Table 4.

The results in Table 4 indicate that the empirical estimates exhibit robustness. Specifically, the financialization behavior driven by reservoir motives demonstrates an inverted “U-shaped” relationship with R&D innovation crowding out. Conversely, due to behavioral heterogeneity related to substitution motives, the relationship between the level of financialization and R&D innovation crowding out appears inconclusive and statistically insignificant.

Table 4 reports the robustness tests of financialization behavior concerning reservoir and substitution motives on R&D innovation crowding out among non-financial listed companies in the Chinese mainland. The empirical regression results in Table 4 reveal that, under different estimation methods, financialization behavior driven by reservoir motives consistently shows a positive coefficient for the first-order regression and a negative coefficient for the second-order regression, both statistically significant at the 1% level. This conclusion aligns with the earlier empirical findings.

Table 4. Empirical results of robustness tests.

	2SLS (1)	SGMM (2)	DGMM (3)	2SLS (4)	SGMM (5)	DGMM (6)
	Coe	Coe	Coe	Coe	Coe	Coe
L.Xsc	3.7640***			4.4452***		
	(19.9122)			(18.1714)		
L.Xsc2				-15.4408***		
				(-2.8149)		
Xsc		1.1286***	1.5336***		1.3948***	1.8017***
		(17.8751)	(12.6625)		(14.2586)	(10.1800)
Xsc2					-4.9375***	-6.3300**
					(-3.9169)	(-2.2697)
L.Td	-0.0000			-0.0000		
	(-0.4698)			(-0.3326)		
L.Td2				-0.0007**		
				(-2.0471)		
Td		0.0000	0.0000		-0.0000	0.0000
		(0.0199)	(1.1980)		(-1.2801)	(0.7551)
Td2					0.0003***	0.0002**
					(3.1565)	(2.2841)
Control Variables	YES	YES	YES	YES	YES	YES
Industry Fixed Effects	YES	NO	NO	YES	NO	NO
Individual Fixed Effects	NO	YES	YES	NO	YES	YES
Time Effects	YES	YES	YES	YES	YES	YES
_cons	-0.0835***	-0.0009	0.0316	-0.0822***	-0.0129	0.0217
	(-7.7034)	(-0.0407)	(0.5529)	(-8.0299)	(-0.5051)	(0.3841)
N	10989	10989	9768	10989	10989	9768

Note: t statistics are in parentheses: *p<.1, **p<0.05, ***p<0.01.

However, regarding financialization behavior driven by substitution motives, the first-order regression coefficients fail to pass the significance test across various estimation methods. Additionally, the sign consistency of the second-order regression coefficients cannot be maintained, leading to an inconclusive and statistically insignificant relationship between enterprise financialization driven by substitution motives and R&D innovation crowding out. From a practical standpoint, the financialization behavior driven by substitution motives often reflects decisions made by agents based on diverse scenarios. Enterprises face a complex array of internal phase-specific characteristics, various attribute features, and external industry traits, rendering the decision-making process of enterprise agents highly heterogeneous. Hence, the relationship between these variables presents differing conclusions when different methodologies are employed, lacking robustness. Further analysis

necessitates the classification and deeper investigation of the sample to address this issue.

4. Further analysis

4.1. Sample classification and basis

The financialization behavior is categorized into two samples: those with R&D innovation crowding-out effect and those without. Samples, where the crowding-out value is negative, are regarded as instances where enterprise financialization impacts R&D innovation with a crowding-out effect, while positive crowding-out values denote instances where enterprise financialization does not crowd out R&D innovation.

For samples exhibiting a crowding-out effect, the decision-making behind enterprise financialization behavior is influenced by two key aspects. First, it stems from investors' portfolio strategies. Corporate financial assets essentially compose an asset portfolio. During a decline in operating profit margins, companies tend to reduce operational investments, favoring increased investments in financial assets. This shift exerts a crowding-out effect on R&D innovation. In the process of portfolio management, compared to operational assets, the increased profit opportunities from financial assets lead agents to prefer channeling funds into the financial sector. Consequently, holding financial assets limits the investment space for R&D innovation, thereby restricting the company's long-term planning. Secondly, this behavior stems from external changes in average profit rates. As the global economic and marketing environment evolves, companies, faced with intense market competition and expanding production capacities, encounter issues such as oversupply and insufficient demand at the entity-level economy. In response to these external pressures, the propensity for investment in R&D innovation technology is weakened, and the capital initially invested in R&D innovation is diverted to seek new investment channels, further reducing investments in R&D innovation. The pressures of market competition and insufficient resources encourage companies to engage in speculation rather than technological innovation. Even companies with outstanding performance, under the agency mechanism, tend toward speculative activities due to competitive pressures, resulting in a crowing-out effect on investments in R&D innovation.

For samples without an R&D innovation crowing-out effect, there might be some degree of financialization behavior, but the objectives and types of financial asset allocation differ from those with a crowing-out effect. In the absence of an R&D innovation crowding-out effect, enterprises tend to favor long-term equity capital allocation in their financialization process. This behavior originates from two major reasons. First, it is driven by strategic needs. As companies strive for long-term development in a market-oriented economy, they aim to expand production scale and acquire a larger market share to leverage economies of scale. In pursuing economies of scale, the scarcity of resources and liquidity necessitate capital expansion. As enterprises expand their capital strategies, product producers gradually transform into strategic investors, allocating more assets to the R&D innovation sector as a necessary path. R&D innovation itself demands substantial funding and involves high uncertainty, prompting companies to invest through financial market financing, inevitably increasing long-term equity investments. However, this increase in the level of financialization does not lead to significant crowding-out effects on R&D innovation. Second, the differences in characteristics among different categories of financial assets result in an absence of crowding-out effects as the level of financialization increases. Companies allocating equity assets to strategic investments in R&D

innovation have long-term expectations, stable investment behavior, clear intent, and emphasize long-term returns and strategic alignment. These long-term equity assets differ significantly from short-term equity assets. From the perspective of corporate fund management, based on the theory of cash asset demand, long-term equity investment entails high conversion adjustment costs, longer time horizons, and difficult estimations of certain hidden losses, thereby relatively reducing the degree of crowding-out effects on R&D innovation.

Moreover, different categories of financialization behavior exhibit distinct operational mechanisms, reflected in the parameter positions for state transitions.

4.2 Comparison of characteristics between two sample types

This sub-section aims to categorize the whole sample based on the criterion of whether there is a crowding-out effect on R&D innovation, in order to compare the impact of different sample types' reservoir and substitution motives in financialization behavior on the crowding-out effect of R&D innovation. Subsequently, an analysis is conducted on the impact characteristics of financialization motives for R&D innovation within these two sample types.

Regarding the influence of different motives in financialization behavior on the crowding-out effect, the research design is entirely consistent with the aforementioned plan, differing only in the empirical process where the whole sample is divided into samples with and without the R&D innovation crowding-out effect. Accordingly, we estimated the parameters in Model (1) using two sub-samples. The parameter estimation method remains OLS, while considering model adaptability, employing a fixed-effects model, yielding parameter estimation results as depicted in Table 5. The first and second columns show the parameter estimates of enterprises with R&D innovation crowding-out effect, where Column (1) is the fixed effects model controlling the industry, denoted as IFE1 (1), and Column (2) is the fixed effects model controlling the individual, denoted as IFE2 (2). The parameter estimates of enterprises with R&D innovation non-crowding-out effect are presented in Columns (3) and (4), where Column (3) is the fixed effects model controlling the industry, denoted as IFE1 (3), and Column (4) is the fixed effects model controlling the individual, denoted as IFE2 (4).

From Table 5, it is observed that the financialization reservoir motive in enterprises exerts a restraining effect on R&D innovation crowding out in both sample types, yet this restraint exhibits heterogeneity across different crowding-out categories. Conversely, the financialization substitution motive strengthens the crowding-out effect on the sample with R&D innovation crowding out but does not show a significant effect on the non-crowding-out sample. On one hand, regarding the reservoir motive in financialization, the core explanatory variables of the reservoir motive in Columns (1) to (4) of Table 5 are significant at the 1% level, the empirical results here demonstrate that regardless of the sample type (i.e., R&D innovation crowding-out or non-crowding-out samples), the reservoir motivation of financialization significantly restrains the crowding-out effect on enterprise R&D innovation. A comparison of the estimated regression coefficients between Columns (1) to (4) reveals heterogeneous impacts of reservoir motivation on the crowding-out of R&D innovation across different sample types. Specifically, within both industry-fixed effects and individual-fixed effects, the inhibitory effect of reservoir motivation on the crowding-out of R&D innovation in non-crowding-out samples is stronger than in R&D innovation crowding-out samples, confirming the earlier theoretical analyses.

Table 5. Empirical results of the crowing-out and non-crowing-out impact of financialization motivation on R&D innovation.

	IFE1 (1)	IFE2 (2)	IFE1 (3)	IFE2 (4)
	Coe	Coe	Coe	Coe
Xsc	2.3785***	2.3861***	3.0983***	2.5084***
	(15.7360)	(39.6509)	(17.1257)	(35.6539)
Td	-0.0010**	-0.0002	-0.0000	0.0000
	(-2.3063)	(-0.7581)	(-0.2684)	(0.0630)
Shrcr	0.0001***	0.0002***	0.0002***	-0.0000
	(2.9366)	(5.5093)	(3.3438)	(-0.6497)
SA	-0.0032***	-0.0142***	-0.0113***	0.0116
	(-2.6482)	(-3.0316)	(-4.0777)	(1.5290)
Cfo	0.0081**	0.0030	0.0696***	0.0174***
	(2.3836)	(0.8157)	(6.2228)	(2.6428)
Fixed	0.0034	0.0127***	-0.0260***	0.0252***
	(1.4239)	(3.4975)	(-3.7755)	(4.8512)
Roa	0.0037	0.0103***	-0.0412***	-0.0078
	(1.2455)	(3.8255)	(-3.6235)	(-1.2287)
Lev	0.0078***	0.0170***	0.0191***	0.0177***
	(3.6854)	(6.0873)	(5.6960)	(4.5991)
Industry Fixed-Effects	YES	NO	YES	NO
Individual Fixed-Effects	NO	YES	NO	YES
Time Effects	YES	YES	YES	YES
_cons	-0.0425***	-0.1015***	-0.0225*	0.0597**
	(-6.7835)	(-5.7242)	(-1.7591)	(2.1036)
N	4300	4300	7910	7910

Note: t statistics are in parentheses: *p<.1, **p<0.05, ***p<0.01.

On the other hand, the estimation of the core explanatory variable, substitute motivation, reveals a significant negative effect at the 1% level only in Column IFE1 (1). However, the estimated coefficients in other scenarios, accompanied by varying control effects and changes in sample types, are non-significant. This indicates that the substitute motivation of financialization only significantly reinforces the crowding-out effect on R&D innovation in samples exhibiting R&D innovation crowding-out, without a significant impact on R&D innovation in non-crowding-out samples. Assessing the estimated regression coefficients of substitute motivation across Columns (1) to (4), its impact on the crowding-out of R&D innovation in both types of samples displays heterogeneity. Particularly, the strengthening effect of substitute motivation on R&D innovation crowding-out samples is significantly higher than in non-crowding-out samples.

Furthermore, evaluating the estimated regression coefficients of both reservoir and substitute motivations across Columns (1) to (4) reveals that irrespective of R&D innovation crowding-out or non-crowding-out samples, the impact of reservoir motivation on the crowding-out of R&D innovation is greater than that of substitute motivation.

The emergence of these features is intricately linked to corporate development planning. On the one hand, when substitute motivation predominates within enterprises, those experiencing R&D innovation crowding-out tendencies tend to invest more in financial assets in the short term rather than augmenting R&D innovation for the enterprise's long-term development. In pursuit of short-term excess profits, the management tends to allocate a significant portion of operational funds into financial assets, thereby constricting the developmental space for R&D innovation and reinforcing the crowding-out effect. It is evident that enterprises with R&D innovation crowding-out tendencies, driven by substitute motivation, overlook the long-term benefits of R&D innovation investment for immediate gains, thereby intensifying the crowding-out effect.

On the other hand, contrasting enterprises with R&D innovation non-crowding-out tendencies, these entities prioritize the company's innovation level and long-term development for sustainable growth. Within the R&D innovation non-crowding-out sample, the reservoir motivation leads to the allocation of corresponding financial assets, accumulating more liquid funds to safeguard against inadequate investment and financing constraints during the R&D innovation process. Hence, the reservoir motivation tends to dominate in samples without R&D innovation crowding-out tendencies, aiding in addressing issues related to lengthy investment cycles in R&D innovation by purchasing relevant financial assets and thus suppressing the crowding-out effect on R&D innovation.

5. Conclusions

Based on econometric models, we statistically identified the crowding-out effect of financialization on R&D innovation behavior. We explored the influence of different behavioral motives during the financialization process on the crowding-out effect on R&D innovation, investigated the dynamic relationship between different behavioral motives and the level of financialization, and studied the basic characteristics of the crowding-out effect of financialization on R&D innovation through sub-sample analysis. The following conclusions are drawn.

First, the impact of enterprise financialization on the crowding-out effect of R&D innovation is closely associated with corporate motives. When enterprise financialization is driven by the reservoir motive, there is an inverted U-shaped relationship between enterprise financialization level and the crowding-out effect on R&D innovation. However, when enterprise financialization is driven by substitution motives, the relationship between enterprise financialization level and R&D innovation is not significant. This lack of significance is highly correlated with the behavioral heterogeneity in substitution motives. There is a strong correlation between the shift in corporate behavioral motives from reservoir to substitution and the short-term profit incentive effect of financialization behavior.

Second, the effects of enterprise financialization motives differ among different types of samples. Financialization behavior exhibits distinct characteristics in its impact on the crowding-out effect of R&D innovation across different sample types. The study categorized the sample into two groups: those with and without the crowding-out effect on R&D innovation. Empirical evidence from these sub-samples shows that financialization driven by the reservoir motive has a suppressive effect on R&D innovation crowding out in both types of samples, albeit with heterogeneity in the suppressive effect across different crowding-out categories. On the other hand, financialization driven by substitution motives strengthens the crowding-out effect in the crowding-out sample but lacks significance in the non-crowding-out sample.

Furthermore, the mechanism variables of financialization behavioral motives exhibit differences

across various samples. Equity concentration shows a moderating effect in both mechanisms of financialization on R&D innovation, with heterogeneous moderation intensities across different sample types. Financing constraints exhibit heterogeneous moderating effects in both types of samples, specifically influencing the reservoir motive and exhibiting varying moderation effects in different sample types while showing no moderating effect on substitution motives.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare that there are no conflicts of interest.

References

1. L. A. Hall, S. Bagchi-Sen, A study of R&D, innovation, and business performance in the Canadian biotechnology industry, *Technovation*, **22** (2002), 231–244. https://doi.org/10.1016/S0166-4972(01)00016-5
2. G. J. Prah, Innovation and economic performance: the role of financial development, *Quant. Financ. Econ.*, **6** (2022), 696–721. https://doi.org/10.3934/qfe.2022031
3. Y. F. Wang, J. Liu, X. R. Yang, M. Shi, R. Ran, The mechanism of green finance's impact on enterprise' sustainable green innovation, *Green Financ.*, **5** (2023), 452–478. https://doi.org/10.3934/gf.2023018
4. K. J. Klassen, J. A. Pittman, M. P. Reed, S. Fortin, A cross-national comparison of R&D expenditure decisions: tax incentives and financial constraints, *Contemp. Account. Res.*, **21** (2004), 639–680. https://doi.org/10.1506/cf2e-huvc-gafy-5h56
5. K. Guo, X. M. Guo, J. Zhang, Financial asset allocation duality and enterprise upgrading: empirical evidence from the Chinese A-share market, *Humanit. Soc. Sci. Commun.*, **10** (2023), 237. https://doi.org/10.1057/s41599-023-01683-1
6. S. Orazi, L. B. Martinez, H. P. Vigier, Determinants and evolution of financial inclusion in Latin America: a demand side analysis, *Quant. Financ. Econ.*, **7** (2023), 187–206. https://doi.org/10.3934/qfe.2023010

7. Z. H. Li, B. Mo, H. Nie, Time and frequency dynamic connectedness between cryptocurrencies and financial assets in China, *Int. Rev. Econo. Finance*, **86** (2023), 46–57. https://doi.org/10.1016/j.iref.2023.01.015
8. Y. Liu, Z. H. Li, M. R. Xu, The influential factors of financial cycle spillover: evidence from China, *Emerg. Mark. Financ. Tr.*, **56** (2020), 1336–1350. https://doi.org/10.1080/1540496x.2019.1658076
9. Z. H. Li, J. H. Zhong, Impact of economic policy uncertainty shocks on China's financial conditions, *Financ. Res. Lett.*, **35** (2020), 7. https://doi.org/10.1016/j.frl.2019.101303
10. I. Yarba, A. D. Yassa, Does stock market listing boost or impede corporate investment, *Borsa Istanb. Rev.*, **22** (2022), 285–294. https://doi.org/10.1016/j.bir.2021.04.001
11. Y. Q. Gao, Z. S. Wang, K. H. Wang, R. A. I. Zhang, Y. C. Lu, Effect of big data on enterprise financialization: evidence from China's SMEs, *Technol. Soc.*, **75** (2023), 102351. https://doi.org/10.1016/j.techsoc.2023.102351
12. Y. H. Huang, L. Sun, T. B. Ger, An analysis of enterprise resource planning systems and key determinants using the Delphi method and an analytic hierarchy process, *Data Sci. Financ. Econ.*, **3** (2023), 166–183. https://doi.org/10.3934/dsfe.2023010
13. J. H. Ma, Z. H. Li, Measuring China's urban digital economy, *Natl. Account. Rev.*, **4** (2022), 329–361. https://doi.org/10.3934/nar.2022019
14. Z. Li, H. Chen, B. Mo, Can digital finance promote urban innovation? Evidence from China, *Borsa Istanb. Rev.*, **23** (2023), 285–296. https://doi.org/10.1016/j.bir.2022.10.006
15. Z. Li, G. Liao, K. Albitar, Does corporate environmental responsibility engagement affect firm value? The mediating role of corporate innovation, *Bus. Strategy Environ.*, **29** (2019), 1045–1055. https://doi.org/10.1002/bse.2416
16. J. R. Brown, B. C. Petersen, Cash holdings and R&D smoothing, *J. Corp. Financ.*, **17** (2011), 694–709. https://doi.org/10.1016/j.jcorpfin.2010.01.003
17. D. Liu, Z. Y. Li, H. B. He, W. X. Hou, The determinants of R&D smoothing with asset sales: Evidence from R&D-intensive firms in China, *Int. Rev. Econ. Financ.*, **75** (2021), 76–93. https://doi.org/10.1016/j.iref.2021.03.013
18. J. Duan, T. T. Liu, X. R. Yang, H. Yang, Y. W. Gao, Financial asset allocation and green innovation, *Green Financ.*, **5** (2023), 512–537. https://doi.org/10.3934/gf.2023020
19. M. Shugurov, International cooperation on climate research and green technologies in the face of sanctions: the case of Russia, *Green Financ.*, **5** (2023), 102–153. https://doi.org/10.3934/gf.2023006
20. L. Liu, M. Liu, How does the digital economy affect industrial eco-efficiency? Empirical evidence from China, *Data Sci. Financ. Econ.*, **2** (2022), 371–390. https://doi.org/10.3934/dsfe.2022019
21. K. F. Xu, Y. Liu, Z. Y. Liu, Dynamic game model for R&D strategy in high-tech enterprises, *J. Differ. Equ. Appl.*, **29** (2023), 143–164. https://doi.org/10.1080/10236198.2023.2182152
22. Z. H. Li, J. H. Zhu, J. J. He, The effects of digital financial inclusion on innovation and entrepreneurship: A network perspective, *Electron. Res. Arch.*, **30** (2022), 4697–4715. https://doi.org/10.3934/era.2022238
23. M. Hong, J. J. He, K. X. Zhang, Z. D. Guo, Does digital transformation of enterprises help reduce the cost of equity capital, *Math. Biosci. Eng.*, **20** (2023), 6498–6516. https://doi.org/10.3934/mbe.2023280

24. Z. H. Li, Z. M. Huang, Y. Y. Su, New media environment, environmental regulation and corporate green technology innovation: evidence from China, *Energy Econ.*, **119** (2023), https://doi.org/10.1016/j.eneco.2023.106545
25. D. Sheng, O. Guyot, Corporate governance in Chinese manufacturing sector: ownership structure, monitoring and firms' earning quality, *Natl. Account. Rev.*, **5** (2023), 421–443. https://doi.org/10.3934/nar.2023024
26. Y. Wen, Y. Xu, Statistical monitoring of economic growth momentum transformation: empirical study of Chinese provinces, *AIMS Math.*, **8** (2023), 24825–24847. https://doi.org/10.3934/math.20231266
27. Ö. Orhangazi, Financialisation and capital accumulation in the non-financial corporate sector: A theoretical and empirical investigation on the US economy: 1973–2003, *Camb. J. Econ.*, **32** (2008), 863–886. https://doi.org/10.1093/cje/ben009
28. W. Lazonick, D. J. Teece, Introduction: management innovation–Essays in the spirit of Alfred D. Chandler, Jr, *Ind. Corp. Change*, **19** (2010), 295–296. https://doi.org/10.1093/icc/dtq014
29. Z. J. Xie, J. Du, Y. C. Wu, Does financialization of non-financial corporations promote the persistence of innovation: evidence from A-share listed manufacturing corporations in China, *Eur. Bus. Rev.*, **12** (2022), 229–250. https://doi.org/10.1007/s40821-021-00193-x
30. Z. Li, C. Yang, Z. Huang, How does the fintech sector react to signals from central bank digital currencies, *Financ. Res. Lett.*, **50** (2022), 103308. https://doi.org/10.1016/j.frl.2022.103308
31. Z. H. Li, H. Dong, C. Floros, A. Charemis, P. Failler, Re-examining Bitcoin volatility: a CAViaR-based Approach, *Emerg. Markets Financ. Trade*, **58** (2022), 1320–1338. https://doi.org/10.1080/1540496x.2021.1873127
32. Z. Li, L. Chen, H. Dong, What are bitcoin market reactions to its-related events, *Int. Rev. Econ. Financ.*, **73** (2021), 1–10. https://doi.org/10.1016/j.iref.2020.12.020
33. H. J. Kim, P. Sohn, J. Y. Seo, The capital structure adjustment through debt financing based on various macroeconomic conditions in Korean market, *Invest. Econ.*, **74** (2015), 155–172. https://doi.org/10.1016/j.inveco.2015.11.005
34. S. Y. Huang, X. Liu, D. Lou, C. Polk, The booms and busts of beta arbitrage, *Manage. Sci.*, 2023. https://doi.org/10.1287/mnsc.2023.4929
35. Z. Q. Zhang, Z. Su, F. Tong, Does digital transformation restrain corporate financialization? Evidence from China, *Financ. Res. Lett.*, **56** (2023), 104152. https://doi.org/10.1016/j.frl.2023.104152
36. W. Li, L. H. Chen, S. He, The effect of enterprise financialization on green innovation: evidence from Chinese A-share non-financial listed enterprises, *Environ. Sci. Pollut. Res.*, **30** (2023), 56802–56817. https://doi.org/10.1007/s11356-023-26377-8
37. C. H. Xu, H. K. Zhang, M. S. Wang, A. Iqbal, Investigating the relationship between entity financialization, managers' incentives, and enterprise's innovation: fresh evidence from China, *Front. Psychol.*, **12** (2022), 810294. https://doi.org/10.3389/fpsyg.2021.810294
38. S. Kim, H. Lee, J. Kim, Divergent effects of external financing on technology innovation activity: Korean evidence, *Technol. Forecast. Soc. Change*, **106** (2016), 22–30. https://doi.org/10.1016/j.techfore.2016.02.002
39. H. Y. Gao, H. Y. Wen, X. J. Wang, Pandemic effect on corporate financial asset holdings: precautionary or return-chasing, *Res. Int. Bus. Financ.*, **62** (2022), 101750. https://doi.org/10.1016/j.ribaf.2022.101750

40. H. Tan, X. H. Zhang, L. L. Zeng, Operating leverage, equity incentive, and enterprise research and development investment, *Sustainability*, **15** (2023), 7023. https://doi.org/10.3390/su15097023
41. Y. Liu, L. M. Chen, H. Luo, Y. Z. Liu, Y. X. Wen, The impact of intellectual property rights protection on green innovation: A quasi-natural experiment based on the pilot policy of the Chinese intellectual property court, *Math. Biosci. Eng.*, **21** (2024), 2587–2607. https://doi.org/10.3934/mbe.2024114