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Research article

Threshold effects of financialization on enterprise R&D innovation: a comparison research on heterogeneity

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Abstract: By taking samples of 1221 non-financial listed companies in China from 2010 to 2019, threshold effects of financialization on enterprise R&D innovation, as well as heterogeneous impacts of the threshold effects in different enterprise types are analyzed by using panel threshold model. The research shows that there are threshold effects of financialization on enterprise R&D innovation, and these threshold effects are heterogeneous among different types of enterprises. To be specific, first, in groups with different ownership structures, the inhibiting effect of state-owned enterprises financialization on R&D innovation decreases with the increase of financialization, while the impact of financialization of non-state-owned enterprises on R&D innovation is firstly promoted and then inhibited with the increase of financialization. Second, in groups with different financing constraints, the inhibiting effect of financialization with high financing constraints enterprises on R&D innovation decreases significantly with the increase of financialization, while the effect of financialization with low financing constraints enterprises on R&D innovation changes from an insignificant promoting effect to a significant inhibiting effect with the increase of financialization. These conclusions provide empirical evidence for different types of enterprises on how to balance the relationship between financialization and R&D innovation.

Keywords: financialization; R&D innovation; threshold effect; heterogeneity

JEL Codes: C23, D00, O32

Abbreviations: R&D: research and development; SOE and NSE: state-owned enterprise and non-state-owned enterprise respectively; HFC and LFC: enterprise with high and low financing constraints respectively

1. Introduction

Innovation is the fundamental driving force for economic development and a key to improving the quality and efficiency of economic development. The global scientific and technological innovation is intensive and dynamic, which drive new technologies, industries and models developing rapidly. At present, China is at a stage of transition from high-speed growth to high-quality development. The key of high-quality development stage is that the strategy of economic development needs to transfer pursuing quantity to quality by optimizing industrial structure (Li and Li, 2020), enhancing innovation ability and improving total factor productivity, thus improving the stability of economic growth. Innovation plays an important role in the process of promoting high-quality economic development. Enterprise innovation includes R&D innovation and non-R&D innovation. R&D innovation includes the internal independent R&D innovation and R&D innovation through technology commissioned or cooperative externally. Non-R&D innovation refers to innovative activities other than R&D innovation, including technology adoption, incremental changes, imitation, and combining existing knowledge in new ways (Anthony et al., 2008). R&D innovation is an important way for enterprises to carry out innovation. Through R&D innovation, enterprises can acquire new knowledge and technology, and then drive enterprise innovation. Therefore, this paper focuses on enterprise R&D innovation. As the most fundamental market entity, enterprise is the backbone to promote economic growth, it also acts as a core force to implementing the national strategy. The capabilities of research and development (R&D) innovation in market economy, on the one hand, they determine the strategic position, competitive advantage and market value for enterprises. On the other hand, they also decide the return on investment (Porter, 1992). The characteristics of long periodicity and large amount of investment make R&D innovation face high innovation risk (Pelikanova, 2019). As a result, enterprise R&D innovation needs sufficient and sustainable capital investment to support their innovation behavior.

The implementation and effectiveness of enterprise R&D innovation are closely related to their investment behavior. Under the background of economic liberalization and globalization, a large amount of capital is gradually deviated from the real economy and invested in real estate and capital markets instead, which results in making a lot of money circulating in financial markets (Krippner, 2005). The excess rate of return on financial investment attracted a large number of companies to participate in financial investment activities (Sukharev and Voronchikhina, 2020), which exerted a certain impact on real economic development. This phenomenon is manifested as “shifted from real to virtual economy” macroscopically, and “enterprise financialization” microscopically. Financialization studied in this paper belongs to microcosmic, which mainly refers to enterprises allocate funds to financial assets with a higher virtual degree. The relationship between financialization and R&D innovation can be roughly classified into types of promotion effect and inhibition effect. Almeida et al. (2004) and Hall (2005) denoted that financial assets have lower adjustment costs and higher cash-ability. Besides, capital investment in financial assets can ease the financing constraints faced by enterprises, so as to better cope with cash flow risks. However, most scholars agreed that there is a substitution relationship between financial assets and R&D innovation, and companies would squeeze

out R&D innovation if they invest more funds in financial assets (Orhangazi, 2008). In addition, some scholars have proposed that there is a nonlinear relationship between financialization and enterprise value (Xu et al., 2020), then investigated that there is a turning point in crowding-out effect of R&D innovation, that is, with the increase of financialization, the crowding-out effect on R&D innovation changes in both degree and direction. To sum up, most of the existing studies focus on the linear relationship between financialization and enterprise R&D innovation, ignoring the nonlinear relationship between them, which leave enough research gaps for this paper. With the improvement of financialization degree, the motivation of enterprises' financialization may change. When the financialization reaches a certain level, the influence effect on enterprise R&D innovation will change. This paper proposes that there is a threshold effect between financialization and R&D innovation. Namely, with the improvement of financialization, there is a turning point in their relationship, and this relationship will change before and after the turning point. In addition, the previous papers rarely investigated whether there are differences in the impact of financialization of different types of firms on R&D innovation, whereas R&D innovation is affected by many factors of firms themselves and the outside world. Therefore, we believe that there is heterogeneity in the threshold effect between financialization and R&D innovation with different firms.

Accordingly, this paper empirically studies the threshold effect of financialization on R&D innovation of enterprises by using relevant data of 1221 Chinese non-financial listed companies from 2010 to 2019, as well as compares the heterogeneity of threshold effect with different types of enterprise from the basic ahead. Compared with previous studies, the main contributions of this paper are as follows. Firstly, considering different national economic positions of enterprises with different ownership structures, as well as various levels of response from national innovation, the heterogeneity of threshold effect between the financialization of state-owned and non-state-owned enterprises on R&D innovation is further investigated. Secondly, influenced by financing constraints to some extent, enterprises with different degree of financing constraints have differences in R&D innovation activities. Therefore, the heterogeneity of threshold effect of enterprises' financialization with high and low financing constraints on R&D innovation based on the different degree of financing constraints is tested.

The remainder of this paper is arranged as follows. Section 2 introduces theoretical analysis and research hypothesis. Section 3 is research design, including sample selection, data source, model construction, index selection and variable measure. Section 4 is the empirical results and analysis, including the threshold effect of financialization on enterprise R&D innovation and heterogeneity in different types of enterprises. Lastly, section 5 concludes our paper.

2. Theoretical analysis and research hypothesis

2.1. The threshold effect of financialization on enterprise R&D innovation

Corporate financialization is a double-edged sword and has a threshold effect on R&D innovation. According to endogenous growth theory, R&D innovation plays a vital role for enterprises to win the market competition and achieve sustainable development. The allocation of financial assets can enhance the liquidity of corporate assets and financial assets have a lower adjustment cost and a higher cash-ability. When faces cash flow risks, financial assets play an important role in easing external financing constraints and thus are conducive to the continuous

development of corporate R&D innovation activities. Ding et al. (2013) claimed that financialization may promote R&D innovation. This may be explained that financial asset allocation activities of enterprises' participation in short-term will increase the assets liquidity and reduce their dependence on external financing, thus offering feedback to the capital shortage that may be encountered in the development of their main business to some extent. Kliman and Williams (2015) found that financialization did not reduce the rate of productive investment during the research on the impact of corporate financialization on productive investment in the United States. This also confirm the assertation that financialization does not have an inhibiting effect on R&D innovation. However, some other aspects, such as characteristics of long cycle and high investment, as well as positive spillover effect on R&D innovation may lead to high risk on innovation. Therefore, enterprises and financial institutions face information asymmetry, which leads to enterprises facing higher financing constraints and not conducive to carry out R&D innovation activities (Hall, 2002). According to the resource-based theory, with external financing constraints and internal funds limitation, enterprise's capital investment in financial assets will inevitably grab the resources of innovation investment. As the market demand is increasingly getting saturated, the profits of real enterprises gradually declined. Induced by the high return rate of financial asset investment, a large amount of capital began to enter the lucrative financial industry, which weakened their main business (Tuzcuoglu, 2020). Such financial speculation in pursuit of short-term returns has a crowding-out effect on long-term innovation investment, which makes enterprises lose the motivation on R&D innovation (Sen and Dasgupta, 2018). Orhangazi (2008) declared that non-financial enterprises have gained more benefits from their investment in financial assets and institutions from the research of the United States from 1973 to 2003, thus their investment of corporate entities would be hindered. Huang, et al. (2021) found that the main purpose of financial asset allocation was to obtain high financial returns based on research of 3493 non-financial listed companies in China from 2007 to 2018. It has a speculative tendency and crowding-out effect on R&D innovation to some extent, which is not conducive to the improvement of enterprises' R&D innovation ability. Besides, a large number of empirical studies have verified that financialization is negatively related with R&D innovation. For example, Gehringer (2013), Trivedi (2014) and Duchin et al. (2017) proved that financialization has a crowding-out effect on entity investment, thus affecting investment efficiency, as well as inhibiting innovation to a certain extent.

However, some other scholars put forward that the relationship between financialization and R&D innovation is not linear. To be specific, their relations will change when the degree of financialization increases to a certain degree. Financialization can effectively improve the rate of capital circulation, expand the financing channels and improve the financing ability timely when their financialization is in low degree (Bonfiglioli, 2008). Therefore, the guarantee of capital input to a certain extent is conducive to the development of enterprise R&D innovation activities. When financialization reaches a certain level, the impact on enterprise R&D innovation will change. Financialization at a high degree will induce fundamental changes to the business model. The mode of resource allocation excessively relies on financial investment occupies the resources that enterprises engaged in R&D innovation activities, and hinders its development as well (Seo et al., 2012). Based on these, this paper assented that there is a non-linear relationship between financialization and R&D innovation, rather than a simple promoting or inhibiting effect. That is to say, with the increase of financialization degree, there is a turning point in the relationship between

financialization and R&D innovation, and this relationship will change around this turning point. From the above, this paper proposes the following hypothesis.

H1: There is a threshold effect on the impact of financialization on enterprise R&D innovation, that is, the degree and direction of the impact of financialization on R&D innovation are different with the variations of financialization levels.

2.2. The heterogeneity of threshold effect of financialization on enterprise R&D innovation

Existing research concerning the heterogeneous impact of financialization on enterprise R&D innovation mainly focuses on the analysis of ownership structure, industry they engaged in and corporate life cycle. Enterprises with different ownership structures have different resource endowments and face to different financing constraints (Huang et al., 2021). Enterprise R&D innovation is an activity requiring continuous capital investment, which lead differences in R&D innovation among enterprises with different ownership structures. Therefore, there may be heterogeneous impact of financialization on R&D innovation for enterprises with different ownership structures. Akkemik and Ozen (2014) declared that enterprises in different industries, their differences on business emphases, demands and modes in R&D innovation input as well, have heterogeneous impact on R&D innovation. Therefore, corporate financialization in different industries has different impacts on R&D innovation. Besides, in view of characteristics of a long cycle of R&D innovation, when enterprises at different life cycles, their focus on business activities are also different, as well as the differences in their capital allocation efficiency, financing constraints, dividend policy, innovation ability and other aspects (Cumming and Johan, 2010; Hall et al., 2016). Therefore, the heterogeneous impact of financialization on enterprise R&D innovation may be mainly reflected in different life cycle stages. From the above, the reasons for the differences in R&D innovation activities among enterprises can be roughly divided into two aspects, such as their own attributes and external environment. The influence for enterprise's own attributes mainly refers to owning resources by themselves, allocating resources reasonably, and their concerns in development stage. The influence of the external environment mainly refers to the financing channels and financing constraints of enterprises. Therefore, from these two perspectives, this paper holds that the heterogeneous impact of financialization on enterprise R&D innovation is mainly reflected in the two aspects of ownership structure and financing constraints.

The influence of ownership structure on R&D innovation has been widely received attention from academic circles. On the one hand, the ownership structure partly reflects the role of the market and the government to some extent, as well as indirectly reflects market intervention from government. As the pillar of the national economy, state-owned enterprises occupy an important strategic position with spreading all over major strategic industries and monopoly industries. Besides, they can get preferential policies and financial support more easily based on their close relations with the government (Tong et al., 2014). Compared with state-owned enterprises, non-state-owned enterprises confronted more fierce market competition. They spent more capital on R&D innovation in order to win the market competition, thus, they gained an advantage in the market competition (Zucker and Darby, 2007). In addition, state-owned enterprises have diversified financing channels, whereas non-state-owned enterprises face more serious financing constraints. Compared with non-state-owned enterprises, state-owned enterprises can obtain bank loans with lower interest rates (Lin and Chen, 2018), thus having more advantages for their R&D innovation (Zhou et al., 2017).

Compared with state-owned enterprises, non-state-owned enterprises face financialization dilemma more passively, which leads to the difference in the impact of financialization on R&D innovation between state-owned enterprises and non-state-owned enterprises. On the other hand, a series of questions, such as how to allocate resources, how to cooperate between owners and operators, and how owners govern the enterprise, are all decided by the ownership structure of an enterprise (Liu et al., 2020). There are some differences in resource endowment among different ownership structures, especially in aspects of enterprise scale, capital, talents, technical level and economic policies. With different ownership structures, the owners and operators of the enterprises will adopt different strategic solutions in R&D innovation activities involving long-term investment. Therefore, the impact of financialization of enterprises with different ownership structures on R&D innovation may be different. Due to the high degree of political connection and extensive financing channels of state-owned enterprises (Zeng and Lin, 2011), the number and intensity of state-owned enterprises' participation in R&D innovation is large. State-owned enterprises' participation in financialization occupies R&D innovation resources, which is not conducive to enterprise R&D innovation. For non-state-owned enterprises, their R&D innovation is largely constrained by funds. For the purpose of profit-driven of financial capital, an appropriate level of financialization can provide funds for R&D innovation of non-state-owned enterprises (Bonfiglioli, 2008), thus promoting the improvement of R&D innovation level of non-state-owned enterprises. However, with the improvement of financialization to a certain extent, financial assets crowded out the R&D innovation assets, which is not conducive to the development of R&D innovation activities of non-state-owned enterprises. Based on the hypothesis 1, this paper puts forward that there is also a threshold effect on the impact of financialization on enterprises R&D innovation with different ownership structures. From the above, we believe that the threshold effect of financialization on R&D innovation is different under different ownership structures. Consequently, we propose the following hypothesis 2.

H2: The heterogeneous impact of threshold effect of financialization on enterprise R&D innovation is mainly reflected in enterprises with different ownership structures.

Corporate R&D innovation activities are affected by financing constraints to some extent. Innovation is a cumulative, collaborative and uncertain process, which requires continuous and large amounts of financial support. Therefore, the innovation activities are restricted by financing constraints to some certain extent (Acharya and Xu, 2017; Brown et al., 2009). Many scholars currently have proved that financing constraints inhibit the improvement of enterprise' R&D innovation ability in their research. When faced external financing constraints, enterprise' investment in R&D innovation activities would be restricted by internal cash flow, and then decreased with the easing of external financing constraints (Brown and Petersen, 2011). Whether the enterprise has sufficient capital will affect its financialization, and thus has a certain impact on its R&D innovation. However, the impact of financialization on R&D innovation varies when enterprise confronts different levels of financing constraints. Compared with enterprises with low financing constraints, higher ones face greater financial pressure and tend to reduce the pressure of cash flow by reducing R&D investment, which makes it difficult to achieve the optimal R&D innovation efficiency (Fazzari, et al., 1987). Corporate R&D innovation are severely constrained by financing, thus making themselves mainly relying on internal financing (Hall, 2002). However, enterprises also have problems of internal financial instability and high cost of innovation adjustment when they support R&D innovation through internal financing (Hall, 2005). Hence, enterprises tend to obtain high financial returns by participating in financialization, and the impact of financialization of enterprises

with different financing constraints on R&D innovation may also be different. Enterprises with high financing constraints are faced with serious financial difficulties. It is not conducive to the development of R&D innovation activities for enterprises to participate in financial investment with limited funds. When the financialization of enterprises with high financing constraints increases to a certain extent, the income brought by financial investment alleviates the capital pressure of enterprises. Hence, the inhibiting effect of financialization on R&D innovation is alleviated. Compared with enterprises with high financing constraints, enterprises with low financing constraints have more abundant funds. Appropriate financialization can provide financial support for enterprises' R&D innovation (Duchin et al., 2017), which is conducive to the improvement of enterprises' R&D innovation level. However, when the financialization of enterprises with low financing constraints increases to a certain extent, the inhibiting effect of financialization on enterprises' R&D innovation becomes prominent. Based on hypothesis 1, this paper holds that there is also a threshold effect on the impact of financialization on R&D innovation in enterprises with different degree of financing constraints. we put forward the following hypothesis 3.

H3: The heterogeneous impact of threshold effect of financialization on enterprise R&D innovation is mainly reflected in enterprises with different financing constraints degree.

3. Research design

3.1. Sample selection and data source

This paper employs 1221 non-financial listed companies in China for the periods of 2010 to 2019. The data of this paper is from CSMAR database. In order to eliminate the possible influence of outliers on the robustness of regression results, we use the Winsorize treatment to the upper and lower 1% for each variable.

3.2. Model

This paper adopts the panel threshold model proposed by Hansen (Hansen, 1999) and takes financialization (*Fin*) as threshold variable to test whether there is a turning point in the impact of financialization on enterprise R&D innovation, and analyzes their threshold effect afterwards. Here is the panel threshold model as follows:

$$Inno_{it} = \beta_0 + \beta_1 Fin_{it} I(Fin_{it} \le r) + \beta_2 Fin_{it} I(Fin_{it} > r) + \sum \alpha_i X_{it} + \varepsilon_{it} \quad (1)$$

where, i and t represent the enterprise and the year respectively. *Inno* stands for enterprise R&D innovation. *Fin* means enterprise financialization, X is a control variable and r is a threshold value. $I(\cdot)$ is an indicator function. The variable *Fin* in the parentheses of the indicator function of this model is taken as the threshold variable, where it meet the conditions in parentheses, the value is 1; otherwise, it is 0. β_1 and β_2 are the coefficient estimates for threshold variables of $Fin_{it} \le r$ and $Fin_{it} > r$ respectively. ε_{it} is a random error term.

In model (1), there is only one default threshold value, but in fact there may be two or more. Therefore, this paper further expands the single-threshold into a double-threshold model:

$$Inno_{it} = \beta_0 + \beta_1 Fin_{it} I(Fin_{it} \le r_1) + \beta_2 Fin_{it} I(r_1 < Fin_{it} \le r_2) + \beta_3 Fin_{it} I(Fin_{it} > r_2) + \sum \alpha_i X_{it} + \varepsilon_{it} \quad (2)$$

where, i and t represent enterprises and years respectively. r_1 and r_2 are the first and second threshold values respectively with $r_2 < r_2$. β_1, β_2 and β_3 are the coefficient estimates of threshold variables of $Fin_{it} \le r_1$, $r_1 < Fin_{it} \le r_2$ and $Fin_{it} > r_2$ respectively. The remaining variable definitions are consistent with model (1).

3.3. Index selection and variable measure

Enterprise R&D innovation (*Inno*) is measured by the proportion of net intangible assets in total assets. The reasons for this measure are as follows although most research used spending on research and development for this index. First, as a result of corporate R&D innovation investment, the intangible assets can reflect the enterprise R&D innovation activities synthetically. Second, enterprise R&D innovation activities involve a wide range. The measure of R&D expenditure cannot fully reflect the enterprise R&D innovation activities which do not include patent rights, copyright, trademark rights and so on (Smith, 2005). Third, this index is not disclosed too much in China's non-financial listed companies.

As for the index of enterprise financialization (*Fin*), in this paper, the financialization of enterprises is measured by the ratio of financial assets to total assets at the end of the period according to the measurement method of Demir (2009). Financial assets include transaction financial assets, investment on real estate, long-term financial equity investment, entrusted financial management and trust products.

In addition, some related variables to control the influence of other firm characteristics on R&D innovation are also introduced. Among numerous influential factors, according to relevant theories and existing empirical studies, we consider other relevant variables that affect enterprises' R&D innovation in the modeling process (Hong et al., 2020; Li et al., 2017; Su and Liu, 2021). When studying the impact of financialization on R&D innovation, other major influencing factors need to be controlled in the econometric test and set as the control variable with the assumption that other influencing factors remain unchanged. In view of characteristics of Chinese listed companies and the influencing factors on enterprise R&D innovation, this paper introduces seven control variables, including net cash flow of operation (*CFO*), company's size (*Lnsize*), the company's capital intensity (*Fixed*), company's age (*Lnage*), net profit margin (*Roa*), company capital structure (*Lev*) and ownership concentration (*Shrcr*). The specific descriptions and calculation method of the above variables are shown in 1.

Table 1. Variables description.

Type of variable	Variable	Variables	Measurement
Dependent variable	Enterprise R&D Innovation	Inno	Proportion of net intangible assets in total assets
Independent variable	Financialization	Fin	Ratio of financial assets to total assets at the end of the period
	net cash flow of operation	CFO	Ratio of net cash flow of operations to total assets at the end of the period
	company size	Lnsize	Taking the natural log from total assets at the end of the period
	company's capital intensity	Fixed	Ratio of fixed assets to total assets at the end of the period
Control variable	Corporate age	Lnage	The present year minus the year of incorporation plus 1 and take the natural log
	net profit margin	Roa	Ratio of net profit to total assets at the end of the period
	corporate capital structure	Lev	Ratio of total liabilities to total assets at the end of the period
	ownership concentration	Shrcr	The sum of the shares held by the top ten shareholders

From descriptive statistics for these variables, Table 2 shows the basic characteristics of 1221 companies' sample data from 2010 to 2019. First of all, for *Inno* in the whole sample, the minimum value is 0.0000, the maximum value is 0.3602, and the average value is 0.0465, which means the level of enterprise R&D innovation is not high from its average sense. At the same time, the minimum value of *Fin* is 0.0004, the maximum value of *Fin* is 0.6380, and the average value of *Fin* is 0.1026, which also means the financialization degree is not high. Secondly, there are differences in the level of R&D innovation and financialization degree among firms with different ownership structures. The average value of *Inno* in state-owned enterprises is 0.0496, which is slightly higher than the average value of *Inno* in whole sample. While the average value of *Inno* in non-state-owned enterprises is 0.0430, which is lower than the average value of *Inno* in whole sample. The average value of *Fin* in state-owned enterprises is 0.1017, which is lower than the average value of *Fin* in whole sample. But the average value of *Fin* in non-state-owned enterprises is 0.1037, which is higher than the average value of *Fin* in whole sample. Finally, there are also differences between the level of R&D innovation and financialization degree among enterprises with different financing constraints degrees. The average value of *Inno* with high financing constraint is 0.0448, which is lower than the average value of *Inno* in whole sample. However, the average value with low financing constraint is 0.0482, which is higher than the average value of *Inno* in whole sample. The average value of *Fin* with high financing constraints is 0.1114, which is higher than the average value of *Fin* in whole sample. However, the average value of *Fin* in enterprises with low financing constraints is 0.0938, which is lower than the average value of *Fin* in whole sample.

Table 2. Descriptive statistics.

Variable	Sample	Obs.	Mean	Std. Dev.	Min	Max
Inno	Full-sample	12,210	0.0465	0.0556	0.0000	0.3602
	SOE	6,490	0.0496	0.0638	0.0000	0.3602
	NSE	5,720	0.0430	0.0441	0.0000	0.3602
	HFC	6110	0.0448	0.0456	0.0000	0.3602
	LFC	6,100	0.0482	0.0639	0.0000	0.3602
Fin	Full-sample	12,210	0.1026	0.1251	0.0004	0.6380
	SOE	6,490	0.1017	0.1235	0.0004	0.6380
	NSE	5,720	0.1037	0.1268	0.0004	0.6380
	HFC	6,110	0.1114	0.1325	0.0004	0.6380
	LFC	6,100	0.0938	0.1166	0.0004	0.6380
CFO	Full-sample	12,210	0.0456	0.0676	−0.1528	0.2353
	SOE	6,490	0.0469	0.0668	−0.1528	0.2353
	NSE	5,720	0.0440	0.0685	−0.1528	0.2353
	HFC	6110	0.0428	0.0675	−0.1528	0.2353
	LFC	6,100	0.0484	0.0676	−0.1528	0.2353
Lnsize	Full-sample	12,210	22.5460	1.3255	20.1727	26.4153
	SOE	6,490	22.9298	1.3815	20.1727	26.4153
	NSE	5,720	22.1106	1.1084	20.1727	26.4153
	HFC	6110	21.5954	0.7021	20.1727	24.8549
	LFC	6,100	23.4981	1.1007	20.3752	26.4153
Lev	Full-sample	12,210	0.4622	0.2037	0.0557	0.8751
	SOE	6,490	0.5087	0.1913	0.0557	0.8751
	NSE	5,720	0.4094	0.2045	0.0557	0.8751
	HFC	6110	0.3693	0.1873	0.0557	0.8751
	LFC	6,100	0.5552	0.1752	0.0557	0.8751
Roa	Full-sample	12,210	0.0389	0.0485	−0.1645	0.1864
	SOE	6,490	0.0360	0.0430	−0.1645	0.1864
	NSE	5,720	0.0423	0.0538	−0.1645	0.1864
	HFC	6110	0.0382	0.0519	−0.1645	0.1864
	LFC	6,100	0.0396	0.0447	−0.1645	0.1864
Growth	Full-sample	12,210	0.1547	0.3889	−0.7541	2.3429
	SOE	6,490	0.1460	0.3577	−0.7541	2.3429
	NSE	5,720	0.1646	0.4214	−0.7541	2.3429
	HFC	6110	0.1368	0.4033	−0.7541	2.3429
	LFC	6,100	0.1727	0.3732	−0.7541	2.3429
Fixed	Full-sample	12,210	0.2193	0.1712	0.0019	0.7251
	SOE	6,490	0.2512	0.1930	0.0019	0.7251
	NSE	5,720	0.1831	0.1335	0.0019	0.7251
	HFC	6110	0.1992	0.1428	0.0019	0.7251
	LFC	6,100	0.2394	0.1935	0.0019	0.7251

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Variable	Sample	Obs.	Mean	Std. Dev.	Min	Max
Lnage	Full-sample	12,210	2.9175	0.2991	1.9459	3.5264
	SOE	6,490	2.9364	0.3016	1.9459	3.5264
	NSE	5,720	2.8962	0.2948	1.9459	3.5264
	HFC	6110	2.9072	0.2920	1.9459	3.5264
	LFC	6,100	2.9279	0.3056	1.9459	3.5264
Shrcr	Full-sample	12,210	56.1159	15.5468	22.5200	90.3800
	SOE	6,490	57.3685	15.5960	22.5200	90.3800
	NSE	5,720	54.6948	15.3689	22.5200	90.3800
	HFC	6110	52.7594	14.4535	22.5200	90.3800
	LFC	6,100	59.4780	15.8746	22.5200	90.3800

Notes: First, the division standard for ownership structure is decided by the actual controller. Second, division of financing constraints is using enterprise' size as the proxy variable to measure the intensity of financing constraints. Low enterprise' scale indicates high financing constraint; otherwise, it is low financing constraints. In this paper, we use median to divide the enterprises size. Among enterprises size from small to large, the top 50% of enterprises in the list are high financing constraints enterprises, while the bottom 50% belong to lower ones.

4. Empirical results and analysis

4.1. Threshold effect of financialization on enterprise R&D innovation

In this section, the threshold effect of financialization on enterprise R&D innovation is tested by the panel threshold regression model. First of all, it is necessary to check whether the model has threshold effect and the number of threshold values before the model parameter estimation. Then, the parameters of the model are estimated (Zheng et al., 2020). In model (1), *Fin* is considered as the threshold variable, which is conducted threshold effect test for 300 times repeated sampling with Bootstrap method. The specific F-statistics and p-values are obtained in Table 3.

Table 3. Results of threshold effect.

Threshold model	F-statistics	p-value	10% Critical value	5% Critical value	1% Critical value
Single threshold	28.36	0.0100	18.0057	21.6851	26.3224
Double threshold	19.87	0.0667	18.6570	21.0564	26.6682
Triple threshold	2.21	0.6833	9.2786	12.4359	18.9371

Table 3 shows the result of the threshold effect of financialization on enterprise R&D innovation. The p-values of single threshold and double threshold effect test are 0.0100 and 0.0667 respectively with passing the significance level test of 10%; while the p-values of triple threshold effect test is 0.6833 without pass. Therefore, the impact of financialization on enterprise R&D innovation has a double threshold, which indicates that there are two turning points for the impact of financialization on R&D innovation. Namely, the relationship between financialization and enterprise R&D innovation will change with the increase of financialization degree. From above, Hypothesis 1 has been verified.

Table 4. Threshold values and confidence intervals of financialization on enterprise R&D innovation.

Threshold	Estimated value	Confidence intervals
First	0.0031	(0.0027, 0.0033)
Second	0.1392	(0.1322, 0.1403)

Table 4 shows threshold values and confidence interval of financialization on enterprise R&D innovation. The first threshold value is 0.0031, and the confidence interval is from 0.0027 to 0.0033. The second threshold is 0.1392, and the confidence interval is from 0.1322 to 0.1403.

Table 5. Regression results of threshold effect.

Variable	Inno
Fin ≤ 0.0031	−2.9064***
	(0.6895)
0.0031 < Fin ≤ 0.1392	0.0013
	(0.0094)
Fin > 0.1392	−0.0328***
	(0.0039)
CFO	0.0178***
	(0.0045)
Lnsize	0.0017**
	(0.0007)
Lev	0.0041
	(0.0029)
Lnage	0.0049**
	(0.0022)
Fixed	0.0194***
	(0.0036)
Roa	−0.0171**
	(0.0073)
Shrcr	−0.0001**
	(0.0000)
Constant	−0.0060
	(0.0118)
Observations	12,210
Number of firmcode	1,221
R-squared	0.0228

Notes: Standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively (the same below).

The regression results in Table 5 indicate that there is a threshold effect between financialization and enterprise R&D innovation. When $Fin \leqslant 0.0031$, financialization has a significant inhibiting effect on R&D innovation with a regression coefficient of −2.9064. When

financialization is in the range from 0.0031 to 0.1392, financialization has a promoting effect on R&D innovation with the regression coefficient of 0.0013 but not significant. When *Fin* > 0.1392, financialization had an inhibitory effect on R&D innovation with a regression coefficient of -0.0328, and the inhibitory effect was much smaller than that of the *Fin* $\leqslant$ 0.0031. The result is in line with the actual situation in China, whose financialization motive has been proved to be mainly invested in speculative financial assets. It also has a crowding-out effect on R&D innovation. When financialization is at a low level, the increase of financial asset allocation shows a strong crowding-out on R&D innovation. However, when financialization is at a high level, their crowding-out effect is alleviated. From the above, enterprises will make financial investment with surplus funds when the financial market is sufficiently developed. On the one hand, it can improve the usage of funds. On the other hand, income from financial investment drives firms to innovate with the profit-driven of financial capital.

In addition, we carry out a two-step robustness check to provide additional support to the empirical results. First, we adopt the measure of enterprise financialization level from the perspective of income as the alternative independent variable and re-run the regressions with panel threshold model. Second, due to the large sample time span, we shorten the sample time span and re-run the regressions with panel threshold model. All the estimated results indicate that there are threshold effects of financialization on enterprise R&D innovation, which means that the empirical conclusion is robust.

4.2. Heterogeneity of the threshold effect of financialization on enterprise R&D innovation

Although the threshold effects of financialization on firm's R&D innovation on the whole can be understood from the above results. However, the heterogeneity of the threshold effect among different types of firms is ignored. The profits from financial assets in different enterprises may be different, like reasons of enterprise risk preference, capital abundance degree and entity investment rate of return. In order to investigate the heterogeneity of threshold effect of financialization on enterprise R&D innovation, the samples are divided according to ownership structure and the degree of financing constraint. According to the ownership structure, enterprises can be divided into state-owned enterprises and non-state-owned enterprises. In addition, enterprises can be divided into high financing constraint enterprises and low financing constraint enterprises according to the degree of financing constraint. Base on the sub-sample, this paper verifies heterogeneity of threshold effect of financialization on enterprise R&D innovation with different enterprises types.

Table 6. Results for threshold effect.

Sample	threshold model	F-value	p-value	10% Critical value	5% Critical value	1% Critical value
SOE	Single threshold	23.37	0.0833	21.8852	25.7085	36.2417
	Double threshold	10.76	0.4433	21.5638	26.8748	37.4992
NSE	Single threshold	29.75	0.0100	19.4504	21.4701	28.7759
	Double threshold	7.03	0.6967	15.8818	20.0472	23.9389
HFC	Single threshold	20.69	0.0800	18.9879	23.853	30.7995
	Double threshold	11.41	0.3867	21.3738	26.6137	33.5058
LFC	Single threshold	24.33	0.0767	21.6946	25.2575	34.4410
	Double threshold	13.93	0.2600	20.0972	21.9637	30.4340

Table 6 shows the results of threshold effects of financialization on R&D innovation with different enterprise types. For state-owned enterprises and non-state-owned enterprises, the p-values of single threshold are 0.0833 and 0.0100 respectively with passing the significance level test of 10%, while the p-values of double threshold are 0.4433 and 0.6967 without a pass. Therefore, there is a single threshold effect between the financialization and R&D innovation for both state-owned enterprises and non-state-owned enterprises, which verifies Hypothesis 2. Simultaneously, for enterprises with high and low financing constraints, the p-values of single threshold are 0.0800 and 0.0767 respectively with passing the significance level test of 10%, while the p-values of double threshold are 0.3867 and 0.2600 without a pass. Therefore, there is also a single threshold effect on the relationship between financialization and R&D innovation for firms with high and low financing constraints, which verifies the Hypothesis 3.

Table 7. Threshold values and confidence intervals of financialization on enterprise R&D innovation.

Sample	Threshold type	Estimated value	Confidence intervals
SOE	First	0.0028	(0.0025, 0.0029)
NSE	First	0.1357	(0.1333, 0.1379)
HFC	First	0.0036	(0.0033, 0.0038)
LFC	First	0.1350	(0.1317, 0.1372)

Table 7 shows threshold values and confidence intervals of financialization on R&D innovation with different types of enterprise. The threshold values for state-owned enterprises and non-state-owned enterprises are 0.0028 and 0.1357 respectively. The threshold value for the latter is about 48 times higher, which indicates that there are significant differences in the turning points between financialization and R&D innovation for state-owned enterprises and non-state-owned enterprises. The threshold values of high and low financial constrained firms are 0.0036 and 0.1350 respectively. The threshold value for the latter is about 38 times higher, which indicates that there are significant differences in the turning points of the relationship between financialization and R&D innovation for high and low financial constrained enterprise.

The regression results in Table 8 indicate that there are significant differences in the threshold effect between financialization and R&D innovation of enterprises with different ownership structures. For state-owned enterprises, as $Fin \leq 0.0028$, financialization has a significant inhibiting effect on R&D innovation with an estimated coefficient of −6.1250; however, as $Fin > 0.0028$, financialization also has an inhibitory effect with a regression coefficient of -0.0568, which is much smaller than the one when the $Fin \leq 0.0028$. For non-state-owned enterprises, when $Fin \leq 0.1357$, financialization has a significant promoting effect on R&D innovation with an estimated coefficient of 0.0380. But when $Fin > 0.1357$, financialization has a significant inhibiting effect with regression coefficient of −0.0193. On the whole, the financialization of state-owned enterprises inhibits R&D innovation, but the inhibiting effect drops sharply when financialization reaches 0.0028. The financialization of non-state-owned enterprises also has an inhibiting effect on R&D innovation when the degree of financialization is low; whereas financialization has a promoting effect on R&D innovation when the financialization reaches 0.1357.

Table 8. Heterogeneity of threshold effect with different ownership structures.

Variable	SOE	Variable	NSE
Fin ≤ 0.0028	−6.1250***	Fin ≤ 0.1357	0.0380***
	(1.3236)		(0.0128)
Fin > 0.0028	−0.0568***	Fin > 0.1357	−0.0193***
	(0.0063)		(0.0049)
CFO	0.0253***	CFO	0.0085
	(0.0063)		(0.0065)
Lnsize	−0.0032***	Lnsize	0.0057***
	(0.0011)		(0.0010)
Lev	−0.0054	Lev	0.0074*
	(0.0045)		(0.0039)
Lnage	0.0143***	Lnage	−0.0077**
	(0.0030)		(0.0035)
Fixed	0.0020	Fixed	0.0382***
	(0.0049)		(0.0054)
Roa	−0.0190	Roa	−0.0199**
	(0.0117)		(0.0093)
Shrcr	0.0001*	Shrcr	−0.0002***
	(0.0001)		(0.0000)
Constant	0.0825***	Constant	−0.0593***
	(0.0183)		(0.0155)
Observations	6,490	Observations	5,720
R-squared	0.0228	R−squared	0.0413

The reason for this phenomenon may be explained that, under the background of national innovation driven strategy, state-owned enterprises have higher enthusiasm on participating in R&D innovation under the management of relevant government departments. During this process, financial assets of corporate allocation will "crowd out" R&D innovation; while, the income gained from the surplus allocation of financial assets can help enterprise innovation when the financial development reaches a certain scale, thus, the inhibition effect will be alleviated. Compared with state-owned enterprises, non-state-owned enterprises have relatively single financial objectives, mainly aiming at maximizing shareholder value. When the financialization level is low, enterprises spend less on the investment of financial assets but sufficient funds for R&D innovation. At the same time, their R&D innovation will be promoted with the financial support from income obtained from appropriate financialization. When the financialization level is high, enterprises allocate more funds to financial assets and fewer funds to R&D innovation, which is not conducive to enterprise R&D innovation.

The regression results in Table 9 indicate that there are differences in the threshold effect between financialization and R&D innovation of enterprises with different financing constraints. For enterprises with high financing constraints, the financialization has a significant inhibiting effect on R&D innovation with an estimated coefficient of −3.3313 when $Fin \leq 0.0036$. As $Fin > 0.0036$, financialization has an inhibitory effect on R&D innovation with a regression coefficient of −0.0276, which is much smaller than the one that $Fin \leq 0.0036$. For firms with low financing constraints, financialization has a promoting effect on R&D innovation but not significant with an estimated

coefficient of 0.0049 when *Fin* ≤ 0.0028. As *Fin* > 0.0028, financialization had a significant inhibiting effect on R&D innovation with a regression coefficient of −0.0462. On the whole, financialization of enterprises with high financing constraints restrains R&D innovation, but the inhibitory effect on R&D innovation decreases significantly when the financialization reaches 0.0036. As the financialization degree is low, firms with low financing constraint have a promoting effect on R&D innovation, but it is not significant. However, when the level of financialization reaches 0.1350, financialization has a significant inhibiting effect on R&D innovation, which is about twice as large as that of enterprises with high financing constraint when *Fin* > 0.0036. This may be explained that enterprises with high financing constraints have great difficulties in obtaining financing, and their investment in R&D innovation is limited. It is not conducive to R&D innovation if enterprises allocate financial assets. However, with the improvement of financialization degree, financial income drives enterprises to carry out R&D innovation, and the inhibiting effect will be greatly weakened. The financialization motivation has proved to be dominated by speculation in Chinese firms. Compared with high financing constraints, firms with low financing constraints are easier to obtain financing, and their financialization plays a greater role in R&D innovation.

Table 9. Heterogeneity of threshold effect of with different financing constraints.

Variable	HFC	Variable	LFC
Fin ≤ 0.0036	−3.3313***	Fin ≤ 0.1350	0.0049
	(0.7662)		(0.0133)
Fin > 0.0036	−0.0276***	Fin > 0.1350	−0.0462***
	(0.0049)		(0.0064)
CFO	0.0160**	CFO	0.0205***
	(0.0065)		(0.0062)
Lnsize	0.0030***	Lnsize	0.0012
	(0.0010)		(0.0010)
Lev	0.0102***	Lev	−0.0090**
	(0.0039)		(0.0045)
Lnage	0.0007	Lnage	0.0078**
	(0.0033)		(0.0031)
Fixed	0.0404***	Fixed	−0.0064
	(0.0052)		(0.0051)
Roa	−0.0044	Roa	−0.0438***
	(0.0095)		(0.0116)
Shrcr	−0.0001	Shrcr	−0.0001**
	(0.0000)		(0.0000)
Constant	−0.0264	Constant	0.0124
	(0.0172)		(0.0162)
Observations	6,110	Observations	6,100
R-squared	0.0313	R-squared	0.0244

5. Conclusions

By selecting samples of 1221 non-financial listed companies in China from 2010 to 2019, this paper adopts the panel threshold effect model, and further conducts a comparison research on the heterogeneity of different types of firms on the basis of testing the threshold effect of financialization on R&D innovation. The result shows that there is a threshold effect on the impact of financialization on R&D innovation. Specifically, as $Fin \leq 0.0031$, financialization has a significant inhibiting effect on R&D innovation. When range is from 0.0031 to 0.1392, financialization has a promoting effect on R&D innovation, but it is not significant. As $Fin > 0.1392$, financialization has an inhibitory effect on R&D innovation, and the inhibitory effect is much smaller than the one as $Fin \leq 0.0031$. Further, the paper also finds that the threshold effect of financialization on R&D innovation is heterogeneous among different types of firms through sub-sample test.

Firstly, the threshold effect of enterprise financialization with different ownership structures on R&D innovation is heterogeneous. With the increase of financialization degree, the inhibiting effect for state-owned enterprises on R&D innovation is greatly weakened, while the effect of non-state-owned enterprises is firstly promoted and then suppressed. Specifically, for state-owned enterprises, as $Fin \leq 0.0028$, financialization has a significant inhibiting effect on R&D innovation. While as $Fin > 0.0028$, financialization also had an inhibitory effect, but this effect was much smaller than that when $Fin \leq 0.0028$. For non-state-owned enterprises, when $Fin \leq 0.1357$, financialization has a significant promoting effect on R&D innovation. But financialization has a significant inhibiting effect when $Fin > 0.1357$.

Secondly, the threshold effect of enterprises with different financing constraints on R&D innovation is also heterogeneous. With the increase of financialization degree, the inhibiting effect of enterprise with high financing constraint on R&D innovation is greatly weakened; while, and the effect of financialization of enterprise with low financing constraint on R&D innovation is transformed from an insignificant promoting effect to a significant inhibiting effect. To be specific, for enterprises with high financing constraints, as $Fin \leq 0.0036$, financialization has a significant inhibiting effect on R&D innovation. As $Fin > 0.0036$, financialization has an inhibitory effect on R&D innovation, which is much smaller than the one when $Fin \leq 0.0036$. For enterprises with low financing constraints, when $Fin \leq 0.1350$, financialization has a promoting effect on R&D innovation, but it is not significant. When $Fin > 0.1350$, financialization has a significant inhibiting effect.

From the above conclusions, this paper offers the following suggestions. First, easing industry access, encouraging competition between industries, breaking through the monopoly position of the financial industry, balancing the profits of various industries, as well as encouraging and supporting R&D innovation for enterprise, and narrowing the income gap between financial investment and R&D innovation investment, should pay more attention. Second, different types of enterprises should carry out differentiation strategies. For state-owned enterprises, they should pay appropriate attention to the financial market, as well as grasp the quality opportunities of R&D innovation. For non-state-owned enterprises, they need to focus on production and business activities, but not the financial market. For enterprises with high financing constraint, tax incentives should be adopted to relieve the financial pressure, and then offer support for R&D innovation (Howell, 2017). For enterprises with low financing constraint, the entry qualifications and funding channels of investment and finance should be examined strictly in order to reduce the adverse impact of excessive financialization on R&D innovation. Furthermore, this paper also has some limitations. On the one

hand, we have tested that there are threshold effects of financialization on enterprise R&D innovation, but their transmission path and impact mechanism have not been discussed. On the other hand, we proved that financialization can promote enterprises' R&D innovation when state-owned enterprises financialization degree is low, but their specific mechanisms and empirical evidences of financialization promoting R&D innovation are not sufficient. These questions are worth further discussion in the near future.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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