Monetary Policy, Product Market Competition, and Firm Innovation: Evidence from Chinese Listed Companies

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Abstract

Based on product market competition, this paper studies the heterogeneity of monetary policy in promoting firms' innovation. Specifically, taking 1420 listed companies from 2013 to 2018 as samples, this paper estimates the impact of monetary policy and product market competition on R&D investment density, and the moderating effect of competition on policy effect by using the fixed effect model. This study shows that a loose monetary policy shock relaxes firms' financing constraints and increases their R&D investment capacity. In response, firms facing greater competitive pressures in product markets choose to increase their R&D investment density, while firms with less competitive pressures lack incentives for R&D investment.

Keywords: monetary policy, product market competition, R&D investment, enterprise innovation

1. Introduction

Over the past few years, the microscopic effects of monetary policy on heterogeneous enterprises have aroused wide attention from economists. As revealed from existing research, the effect of monetary policy on enterprises' behavior or financial indicators (e.g., investment and financing decisions, asset structure, and financial leakage) is moderated by several enterprise characteristics, thereby exerting policy effects that exhibit asymmetry or heterogeneity at the micro-scale (Shen & Yin, 2016). Thus, a question is raised that whether monetary policy also has a micro-level effect on enterprise innovation.

Recent studies have reported financing constraints as a vital factor hindering innovation in private enterprises and SMEs (Zhang, Liu, Wang & Li, 2017), while monetary policy can impact the financial condition of enterprises and thus their level of R&D investment by tightening or easing the financing environment. To be specific, the eased policy environment weakens the financing constraints of enterprises, enhances their free cash flow, and has a positive moderating effect on R&D investment. However, the existing studies primarily stressed the effect of the financing environment on enterprises' innovative R&D, while placing insufficient emphasis on the factors of enterprises' R&D motivation. For instance, a study by Zhang et al. (2017) reported that private enterprises are more motivated to innovate and conduct R&D than SOEs and are more likely to allocate new investment capacity to R&D expenditure. It is elucidated that since enterprises are heterogeneous in their R&D propensity, when monetary policy shocks enterprises' innovating activities, enterprises will make different R&D investment decisions as determined by their R&D propensity, thereby leading to a micro impact of macro-monetary policy.

The present study determines a new element that influences the relationship between monetary policy and enterprises' R&D investment at the micro level for R&D demand: the competitive pressures that enterprises face in product markets. In accordance with innovation theory, competition is one of the critical factors of enterprises' innovation. As suggested from Arrow's study (1962), for a monopolist, since the enterprise is already in a competitive position in the market and takes up a large market share, continuously increasing its technological advantage cannot bring the enterprise higher returns. In other words, innovation only leads to a substitution between the old and novel monopoly rents, instead of an expansion of earnings; while for a manufacturer in a competitive market environment, the technological advantage endowed by innovation will help the enterprise get rid of fierce competition and exhibit a certain monopoly power, thereby capturing monopoly rents. To be specific, innovation brings the monopoly income that the enterprise did not have before, which is the expansion of the overall income. Therefore, monopoly enterprises are easy to be satisfied with the status quo and only maintain a

low limit of R&D investment to maintain technological advantages. However, enterprises in a competitive environment have more incentive to invest in R&D and select a higher level of R&D investment in the financial constraints. Subsequent research has further summarized the effect of competition on innovation as the escape from competition effect (Aghion & Howitt, 1992; Aghion, Bloom, Griffith, Howitt, & Blundell, 2005; Aghion, Farhi, & Kharroubi, 2012). This effect has also been verified in the Chinese market by Bai and Li (2006) by adopting a database of Chinese industrial enterprises. They argued that competition is more conducive to innovation and productivity. Cao, Bai, and Huang (2009) suggested that competitive pressures on costs and sales force SMEs to carry out innovation. Zhang, Zheng, and Zhai (2014) distinguished between property rights and indicated that in relatively competitive environment, escaping from competition effects is widespread among private enterprises. Dai, Yu, and Zhao (2018) studied the effects of competitive pressure in product markets on enterprise innovation from both export market competition and import competition channels, respectively. In addition, they reported that when currency appreciation poses increased competitive pressure on enterprises in export markets, or when tariff cuts lead to imported and local products, the creation of competition can overall help elevate the number of R&D investments and patent applications by the affected enterprises. Besides avoiding competitive effects, competition in product markets is capable of stimulating innovation in several ways, which consist of by reducing agency costs (Schmidt, 1997) or increasing the acquisition of market share (Raith, 2003).

Thus, a question is raised that how the competitive pressures facing enterprises in product markets play a role in regulating the relationship between monetary policy and enterprise investment in R&D. Take an easing monetary policy shock as the example: Enterprises facing greater competitive pressures in product markets show stronger incentives to undertake R&D to capture monopoly rents, as impacted by the effects of fleeing competition. When such enterprises face an easing policy shock, their R&D investment levels are elevated due to the relaxation of financing constraints and improved financial position. Enterprises with less competitive pressure on product markets are not inclined to expand their technological advantage, while they prefer other investment projects, so their R&D investment levels are not altered significantly regardless of the increased borrowing redundancy.

To verify the mentioned logic, the present study investigates the relationship and mechanism of action between monetary policy shocks, enterprises' return on net worth and their R&D investment density. By referencing S ánchez and Schmitz (2002) and Dai et al. (2018), this study defines competition as the likelihood of an enterprise's closure. In addition, since the likelihood of closure is negatively correlated with profits, a lower ROE implies that enterprises face strong competitive pressure in product market competition. By referencing Zhang et al. (2017), this study measures enterprise innovation by the density of R&D investment, i.e., the share of R&D investment in total sales. If monetary policy turns from loose to tight, it hinders the supply of credit in the financial market, adversely affecting the enterprise's financial position. In such process, if the enterprise faces strong competition in the product market, competitive pressure will force the enterprise to maintain the previous level of R&D investment maximally.

This study shows a relation to the literature on the effect of monetary policy shocks on enterprise investment behavior. Though there is a long history of research on the effect of monetary policy on the economy, studies that focus on the micro impact of policy have only recently begun to emerge. Relevant studies have focused on the effect of monetary policy shocks on the investment and financing decisions of different enterprises (Zeng & Dong, 2010). According to Gertler and Gilchrist (1994) and Rao and Jiang (2013), differences in the characteristics of enterprises (e.g., the nature of property rights, capital structure, size and industry) are vital factors resulting in differences in the effects of monetary policy. Or the heterogeneous impact of capital supply shocks on the investment and financing decisions of Chinese real estate enterprises has been studied through the lens of the nature of property rights (Shen & Yin, 2016). Though the existing literature has extensively explored the characteristics of enterprises that influence the effect of monetary policy, no literature has yet investigated the effect of enterprises' competitive pressure on the micro effects of monetary policy from a competitive perspective. The present study fills the gap in this research perspective.

In addition, the study involves the literature on the enterprises' innovating behavior. Zhang et al. (2017) examined the effect of financing constraints on enterprises from the perspective of credit rent-seeking and proved that the decreased availability of credit funds and higher real financing costs squeezed out enterprises' innovation profits, which in turn inhibited enterprises' innovating activities. As revealed from the results, privatization significantly elevated the level of financing constraint and hindered innovating activities. Besides, several scholars linked enterprises' innovating behavior to competitive pressure in accordance with innovation theory. For instance, Dai et al. (2018) explored the effect of foreign market competition on the innovating activities of exporting enterprises, interpreting how the appreciation of the RMB facilitates exporting enterprises

to boost R&D investment. Though foreign research on the relationship between competition and innovation is relatively more mature, empirical analysis for domestic enterprises remains rarely conducted. The present study determines the effects of monetary policy and competitive pressures in product markets on enterprises' innovation behavior, providing empirical evidence for this study.

The rest of the present study is organized below. In section 2, a theoretical model is built, competition and innovation are introduced by complying with Aghion et al.'s (2012) model, and research hypotheses are proposed. In section 3, the data, the measurement model, and variable definitions are presented. In section 4, the empirical analysis and results are elucidated, and a robustness test is performed. Lastly, in section 5, the conclusions and policy recommendations are drawn.

2. Model

2.1 Baseline Model

In the present study, monetary policy affects enterprises' R&D investment through financing constraints, and product market competition regulates such process. To express this process in the model, the present study introduces R&D investment in the model of Aghion, Kharroubi, Cowell, Ellingsen, and Manning (2019) and simplifies some irrelevant elements, i.e., economic agents consist of enterprises that survive for only two periods, and no generational overlap is identified between enterprises. Enterprises born in period t follow a utility function $U = E[c_{t+2}]$, and an initial endowment A available for R&D investment, where c_{t+2} denotes the enterprise's consumption over the last period. The enterprise is protected by limited liability and completes all investment-related choices in t.

In the transition period (t+1), the enterprise acquires the cash flow benefits $\pi(c)I_{rd}$ from the previous investment, where $\pi(c) \in \{\pi_G(c), \pi_B(c)\}$, and $\pi_G(c) > \pi_B(c)$. $c \in \{\overline{c}, \underline{c}\}$ denotes a parameter measuring the degree of competition in the product market. In addition, since the investment here refers to an R&D project, according to the basic conclusion cited earlier, i.e., the more intense the competition in the product market, the higher the potential returns to the enterprise's R&D will be, $d\pi(c)/dc > 0$, and the return on investment is proportional to the degree of competition. Moreover, in t+1, the enterprise faces shocks of uncertain nature. There are two types of shocks, i.e., a good shock (G) exhibiting α probability, resulting in higher investment income π_G; a bad shock (B) with 1-α probability, adversely affecting the enterprise's investment income π_B and liquidity.

During the R&D investment, the investment capacity is partially liberated by the injection of funds from external investors. Though the mentioned funds cannot be directly invested in R&D projects, the R&D projects take up this investment capacity resulting in opportunity costs, so the R&D project proceeds should assume part of the external financing costs. Based on this setup, a link between enterprises' R&D investment and financing constraints can be built in the model. By referencing the setting of Aghion et al. (2002, 2012), R&D projects assume the financing costs to which they belong to the form of additional earnings, and the cash flow $\pi(c)I_t$ created by the project cannot be collateralized. If the enterprise is not subject to a bad shock in t+1, and the investment project is not harmed, it can earn an additional income $\rho_1 I_{rd}$, where $\rho_1 I_{rd}$ denotes the part that can be pledged to external investors. If the enterprise suffers a bad shock in t+1, it will not be capable of capturing the additional income. To protect the investment project, the enterprise should recapitalize the project $J \leq I_{rd}$. The recapitalized project is capable of earning an additional return $\rho_1 J$ in t+2, where $\rho_0 J$ denotes the portion that can be pledged to an outside investor. The parameter ρ_0 represents the inverse measure of the financing constraint. For an enterprise with the same additional returns, the higher ρ_0, the larger the share of the additional returns that can be collateralized and the smaller the financing constraint the enterprise will face. ρ_0 is impacted by the enterprise's own characteristics and also associated with monetary policy and credit supply. An accommodative monetary policy increases the supply of credit and, to some extent, the enterprise's ability to exchange collateral for credit facilities.

Suppose 1: $\rho_0 < R$ $(R \geq 1)$

Suppose 2: $\pi_G(\underline{c}) < 1 < \pi_G(\overline{c})$ and $1 - \frac{\rho_0}{R} > \pi_B(\overline{c}) > \pi_B(\underline{c})$

where R denotes the real interest rate. Hypothesis 1 ensures that enterprises are constrained in their financing and only use limited scale investments. In hypothesis 2, the status of R&D investment returns is determined under different levels of competition and the relationship between investment returns and liquidity needs. Under a B shock, cash flows in any competitive environment are insufficient to cover the liquidity demands for reinvestment. However, since R&D investment returns are higher in a high-intensity competitive environment, such enterprises raise a lower need for liquidity holdings. To be specific, the liquidity held by enterprises is

denoted by xI_t.

At this point, enterprises need to weigh the trade-offs in their investment decisions: on the one hand, to maximize investment returns, they need to hold as little liquidity as possible and increase the size of their investment, whereas this may cause their inability to reinvest in the project in the event of a B shock; on the other hand, to mitigate the effect of a negative shock, they are required to hold maximal liquidity and sacrifice some of their initial investment.

2.2 Investments in Equilibrium, Liquid Holdings and Reinvestment

To arrive at an equilibrium solution to the enterprise's investment decision, the analysis focuses on the specific situation facing the enterprise in t+1. When facing a B shock, enterprises should carry out reinvesting, and their ability to reinvest is determined by initial liquidity holdings, investment returns and financing constraints.

$$J \leq [x + \pi_B(c)]I_{rd} + \frac{\rho_0 J}{R} \tag{1}$$

Since reinvestment cannot exceed the size of the initial investment, J is written as:

$$J = \min\{\frac{x+\pi_B(c)}{1-\frac{\rho_0}{R}}, 1\}I_{rd} \tag{2}$$

As revealed from the presented equation, lower financing constraints help reinvestment to proceed smoothly. The analysis of the enterprise's trade-offs above points out that the enterprise will not hold more liquidity than it requires, so it can be determined that $x \in [0, 1 + \frac{\rho_0}{R} - \pi_B(c)]$.

To satisfy the investment demand, the R&D project takes up $(I_t - A)$ investment capacity. If no B shock occurs in t+1, the enterprise uses $\rho_0 I_t$ to pay outside investors. If a B shock occurs in t+1, the enterprise reinvests the liquidity it held previously and pays the outside investor $\rho_0 J$ in t+2. Thus, the enterprise's borrowing in t can be described as:

$$I_{rd} - A = \alpha \frac{\rho_0}{R} + (1-\alpha)\frac{\rho_0}{R^2} - (1-\alpha)\frac{xI_{rd}}{R} \tag{3}$$

The final enterprise's R&D investment in t is:

$$I_{rd} = \frac{A}{1+(1-\alpha)\frac{x}{R}-\alpha\frac{\rho_0}{R}-(1-\alpha)\frac{\rho_0}{R^2}} = \frac{A}{1+(1-\alpha)\frac{(1-\pi_B(c))}{R}-\alpha\frac{\rho_0}{R}} \tag{4}$$

Assuming that the enterprise's long-run equilibrium investment is $I_{rd} = s_{rd}A$, the growth rate of R&D investment is obtained as follows.

$$s_{rd} = \frac{I_{rd}}{A} = \frac{R}{R+(1-\alpha)(1-\pi_B(c))-\alpha\rho_0} \tag{5}$$

2.3 Product Market Competition, Financing Constraints and R&D Investments

The objective of the present study is to describe the effect of changes in financing constraints due to monetary policy shocks on enterprises' R&D investment and to analyze the moderating effect of the competitive environment in product markets on this impact. To achieve this objective, a partial derivative analysis of the R&D investment equation obtained above is performed:

$$\frac{\partial s_{rd}}{\partial \rho_0} = \frac{\alpha R}{\{R+(1-\alpha)(1-\pi_B(c))-\alpha\rho_0\}^2} > 0 \tag{6}$$

The above formula illustrates that the growth rate of enterprises' R&D investment is negatively related to the financing constraint (ρ_0 is an inverse measure of the financing constraint). It has been shown that loose monetary policy can alleviate the financing constraint and significantly improve the investment efficiency of enterprises (Jin, Kong, & Hou, 2012). Tight monetary policy shocks, on the other hand, can exacerbate the differences in financing constraints among enterprises, leading to a significant decline in the investment efficiency of enterprises with high financing constraints, e.g., non-state enterprises (Yu, Li, Zhang, & Xu, 2014). With reference to the above findings, it is assumed that the financing constraint is affected by monetary policy, i.e., $\rho_0 = \rho_0(MP)$ and $\rho_0{}'(MP) > 0$. Where MP is a measure of monetary policy, and its positive or negative indicates the direction of the monetary policy shock. It follows that an accommodative monetary policy shock will promote faster growth of enterprises' R&D investment, while a tighter monetary policy shock will dampen R&D investment.

Based on the results of the theoretical model derivation, the present study proposes the following research hypotheses:

Hypothesis 1: Tight monetary policy discourages enterprises' R&D investment, while accommodative monetary policy promotes enterprises' R&D investment.

At the same time, the effect of policy shocks on enterprises' R&D investment is moderated by the degree of product market competition:

$$\frac{\alpha R}{\{R+(1-\alpha)(1-\pi_B(\overline{c}))-\alpha\rho_0\}^2} > \frac{\alpha R}{\{R+(1-\alpha)(1-\pi_B(\underline{c}))-\alpha\rho_0\}^2} \tag{7}$$

$$\left.\frac{\partial s_{rd}}{\partial \rho_0}\right|_{c=\overline{c}} > \left.\frac{\partial s_{rd}}{\partial \rho_0}\right|_{c=\underline{c}} \tag{8}$$

When enterprises face high intensity competition in product markets, benefiting from high returns on R&D investment, the effect of monetary policy on enterprises' R&D investment is enhanced compared to enterprises in market conditions with weaker competitive pressures. That is, enterprises in highly competitive market conditions in product markets tend to more significantly participate in innovating activities, so the investment capacity released by loose monetary policy is more likely to be translated into enterprises' R&D investment, while under tight policy conditions, enterprises miss out on more potential R&D investment activities due to reduced financing capacity. For the mentioned reason, the following research hypothesis is proposed:

Hypothesis 2: The effect of monetary policy on enterprises' R&D investment is moderated by the degree of competition in the product market. The more intense the competition in the product market, the more sensitive the enterprise's R&D investment is to changes in monetary policy.

3. Empirical Analysis Using Listed Companies Data

The enterprise-level sample in the present study is derived from data regarding A-share listed companies in the Wind database from 2013 to 2018, and the sample consists of both state-owned and non-state-owned enterprises in 16 industries. The dataset contains variables from corporate balance sheets, cash flow statements and income statements (e.g., company code, nature of ownership, time of establishment, total assets, total sales, R&D investment and operating cash flow, as well as corporate R&D expenditure and R&D investment from the listed companies' innovation tables). Monetary policy-related data originate from the official website of the People's Bank of China and the Wind database, including the real lending rate, benchmark RMB lending rate, open market reverse repurchase, and medium-term convenience lending operations.

To reduce the effect of missing values and other data factors on the study, we refer to the treatment of Dai et al. (2018) and set up a data sample that is discarded if the data meet one of the following conditions: (1) one or more of the missing data on the nature of ownership, total assets, fixed assets, owner's equity, total liabilities, total sales, R&D expenditure and R&D investment , or negative data; (2) failed to do continuous disclosure of R&D investment during 2013-2018; and (3) financial industry enterprises. After cleaning the data, the final sample contains 1,420 enterprises belonging to 16 industries, with a total of 8,520 observations. To avoid the influence of outliers on the empirical results, Winsor shrinkage was applied to the data at 1% and 99%.

3.1 Variable Selection and Model Setting

To examine the effect of monetary policy shocks and product market competition on enterprises' innovating activities, the following measurement model is developed with reference to the results of the derivation of the theoretical model:

$$RD_{i,t} = c + \beta_0 MP_t + \beta_1 C_{i,t} + \beta_2 MP_t \times C_{i,t} + \epsilon_{i,t} \tag{9}$$

where, $RD_{i,t}$ denotes the level of R&D investment of enterprise i in t. With reference to Zhang et al. (2017), the present study measures this variable by the R&D investment density (R&D investment/operating income). $C_{i,t}$ denotes the competitive pressure facing enterprise i in the product market in t. The competitive pressure in the product market in t is measured by the ratio of R&D investment to business revenue. Referring to S ánchez & Schmitz (2002), the present study defines competitive pressure as the likelihood of an enterprise's failure. The likelihood of an enterprise's failure is negatively related to profits since lower profits increase the competitive pressure on the enterprise. A study by Dai et al. (2018) shows that between 2005 and 2007, the continuous appreciation of the RMB led to a rapid decline in the profit level of exporting enterprises, making exporting enterprises face greater competitive pressure and triggering more innovative activities compared to non-exporting enterprises. With reference to the findings of this study, the present study measures the profit pressure of an enterprise by its return on equity (ROE), which is the competitive pressure the enterprise faces in the product market, i.e., the lower the ROE, the greater the profit pressure will be, the higher the probability of closure will be; thus the greater the competitive pressure it will face in the product market.

$MP_t \times C_{i,t}$ refers to a cross term between monetary policy and competition, determining the effect of product market competition on the efficacy of monetary policy. The MP_t represents the monetary policy in t. Recently, monetary policy has gradually shifted to a price-based one. Over the past few years, monetary policy has gradually shifted to a price-based approach, and the benchmark lending rate (i.e., a conventional instrument) has remained unchanged since 2016. As an alternative, the Central People's Bank of China more frequently leverages a range of policy tools (e.g., standing lending facilities (SLF), mortgage supplement loans (PSL), medium-term lending facilities (MLF) and open market reverse repurchase, more effectively performing the functions to regulate market liquidity and guide money market interest rates, while tools (e.g., the reserve requirement ratio and the lending benchmark interest rate) tend to decline. Combining domestic and international research and China's actual situation, to fully capture central bank monetary policy changes, the present study chooses to use the real lending rate (R) and net open market money injection (M) as proxies for monetary policy, and with reference to Zeng & Su (2010) and Romer (1990), a virtual is set after integrating relevant policy instrument data variables (DM) as a tool to further measure robustness.

Table 1. Monetary policy-related data, 2014-2018

	2013	2014	2015	2016	2017	2018
Real loan interest rate (%)	7.0	7.0	5.9	5.2	5.6	5.9
Open market reverse repurchase (¥ billion)	26180	5540	31580	235700	212250	112500
Base rate for central bank loans (%)	6.15	6.1	5.3	4.8	4.8	4.8
Medium-term lending facilities (¥ billion)	—	11445	32308	55235	50295	39510
Monetary policy dummy variables (DM)	0.0	0.0	0.5	1.0	0.9	0.6

To be specific, based on the trend in the central bank's benchmark lending rate, 2013 and 2014 are set here as the periods of tightest monetary policy in the sample period, taking the value of zero, and 2016 as the period of most accommodative monetary policy, taking the value of one, with the values for the other periods determined by the relative size of the net injection of medium-term lending facilities of that year:

$$DM_t = \frac{MLF_t - MLF_{2014}}{MLF_{2016} - MLF_{2014}} \tag{10}$$

Though Eq. (9) is the core model estimated in the present study, enterprise investment in R&D may also be influenced by other enterprise attributes and industry characteristics. To control for these factors, the present study chooses to control for the enterprise's age, cash flow position, size, growth stage, ownership attributes and the industry in which it operates by referencing relevant literature (Zhang et al., 2017). To be specific, Control is set as the control variable, and the variables include: the age of the enterprise as measured by the enterprise's establishment date (Age); the cash flow status (Cf) as measured by the net cash flow generated by the enterprise's operating activities; the size of the enterprise as measured by the enterprise's total assets (Size); and the growth stage as measured by the growth rate of the enterprise's operating income (Grow).

In addition, because enterprises with different ownership are heterogeneous for their financing environment and innovation R&D propensity, the present study uses a fixed effects model to control for their ownership characteristics. Yu et al. (2014) reported that SOEs' advantage in financing constraints causes the lack of sensitivity of their investment activities to modifications in monetary policy, while financing constraints introduced by the privatization of SOEs can significantly hinder enterprises' innovating activities (Aghion et al., 2012; Zhang et al., 2017).

Moreover, SOEs are overall considered in a monopoly position in the market competition, posing less competitive pressure (Zhang et al., 2014). Such feature of SOEs' low competitive pressure and lack of monetary policy sensitivity complies with the results of the "competitive pressure moderating monetary policy effect" described in the present study. Since the sample contains considerable SOEs, such consistency may cause a spurious correlation. To ensure that the mentioned empirical findings do not originate from differences in property rights, the present study further tests them based on benchmark regressions and finds that, after controlling for property rights, the regression results are basically consistent with those described above, the R&D investment of both SOEs and NPEs are significantly affected by monetary policy and competitive pressure, and the competitive pressure in product markets more significantly moderate monetary policy.

After substituting the control variables, the final measurement model is written as:

$$RD_{i,t} = c + \beta_0 MP_t + \beta_1 ROE_{i,t} + \beta_2 MP_t \times ROE_{i,t} + \sum Control + \epsilon_{i,t} \tag{11}$$

3.2 Empirical Strategy

Table 2 lists the descriptive statistics of the main variables in the model. The average R&D investment density (RD) of the sample enterprises is 5.5%, and a significant difference is identified in the level of investment among enterprises, with a 78% difference between the enterprises with the highest and lowest investment density. The average return on net assets (ROE) is 4.1%, exhibiting a 131% difference in the level of profitability between enterprises at most. It is therefore indicated that a large difference exists in profit pressure between enterprises, i.e., a difference is revealed in the level of competitive pressure on the product market. Industries above such average level are characterized by high market concentration and relatively weak product competition, while the opposite exhibit low market concentration and relatively strong product competition in the industry. As revealed from summary statistics for the three sets of proxies for monetary policy, the degree of monetary policy tightness has varied more significantly over the sample period.

Table 2. Summary statistics for major variables

Variables	Mean	SD	Min	Max
Dependent variable				
RD	0.055	0.030	0.005	0.785
Key independent variable				
R	6.100	0.678	5.200	7.000
ROE	0.041	0.151	-1.150	0.160
Control variable				
Grow	0.374	1.005	-0.800	11.230
Size	22.090	1.117	20.000	25.500
Age	20.831	4.939	12.000	35.000
Cf	19.463	2.830	11.430	22.922

4. Results

4.1 The Basic Conclusion

Table 3 is presented as empirical tests against Hypothesis 1, which primarily show the overall effect of monetary policy and product market competition (ROE) on enterprises' R&D investment, and are the results of the test of Eq. (11) without the cross term. The regression results show that monetary policy has a significant impact on enterprises' R&D investment density, regardless of the indicator measure. The adverse effect of real lending rate and positive impact of net open market money injection and monetary policy dummy variables imply that loose monetary policy stimulates enterprises to increase R&D investment, while tight monetary policy is detrimental to enterprises' innovating activities, which complies with the direction of the model's prediction of the effect of monetary policy on enterprises' R&D investment, hypothesis 1 is verified. Secondly, in the present study, product market competition, as measured by ROE, has an adverse effect on the R&D investment density of enterprises, as opposed to the intuition that an increase in ROE is conducive to enterprises' R&D investment, and to the intuition that competitive pressure helps stimulate enterprises' R&D investment. Innovation" (Dai et al., 2018) complies with the mentioned view, presenting further empirical evidence for the relationship between competitive pressures and enterprises' R&D activities.

Table 3. Baseline regression result

Dependent variable	(1)	(2)	(3)
ROE	-0.010***	-0.010***	-0.010***
	(-6.20)	(-6.12)	(-6.23)
R	-0.003***		
	(-8.36)		
M		1.7e-08***	
		(8.17)	
DM			0.001***
			(8.38)
Grow	0.919***	0.917***	0.917***
	(31.18)	(35.00)	(34.52)

Size	-0.010***	-0.010***	-0.010***
	(-6.20)	(-6.12)	(-6.23)
Age	-0.003***		
	(-8.36)		
Cf		1.7e-08***	
		(8.17)	
_cons			0.001***
			(8.38)
Firm controls	YES	YES	YES
Industry controls	YES	YES	YES
Adj-R2	0.63	0.63	0.63

Note. t statistics in parentheses, * p<0.01, ** p<0.01, *** p<0.01.

Table 4 is presented as empirical tests against Hypothesis 2, highlighting the moderating effect of product market competition (ROE) on the effect of monetary policy on enterprises' R&D investment based on monetary policy's influence on enterprises' R&D investment. The regression results show that product market competition (ROE) more significantly impacts the effect of monetary policy, regardless of the indicator used to measure monetary policy. According to Eq. (11), the total effect of monetary policy on enterprises' R&D investment is:

$$\beta_* = \beta_0 + \beta_2 ROE_{i,t} \qquad (12)$$

Where "*" denotes the monetary policy proxy (R, M or DM). Since the return on equity (ROE) shows a negative relation to the competitive pressure in the product market, the economic meaning of the coefficient β_* can be expressed below: competition in the product market can significantly affect the level of R&D investment, thereby resulting in different marginal returns on R&D investment, which in turn determines the actual impact of monetary policy shocks on the enterprise's R&D investment. Take the real lending rate (R) as an example. A positive cross-currency coefficient (β_2) implies that i.e., the higher the ROE, the lower the competitive pressure in the product market, the lower the marginal returns on enterprises' R&D investment, the less the total impact of monetary policy β_R will be, i.e., even if loose monetary policy helps enterprises release sufficient cash flow and investment capacity, enterprises will not increase their R&D investment projects, and the less the total impact of monetary policy β_R will be, as expressed below:

$$\begin{cases} \beta_R < 0 \\ \frac{\partial \beta_R}{\partial ROE} = 0.002 > 0 \end{cases} \qquad (13)$$

It is also available for:

$$\begin{cases} \beta_{MP} > 0 \\ \frac{\partial \beta_{MP}}{\partial ROE} = (-2.67e-08) < 0 \end{cases} \qquad (14)$$

$$\begin{cases} \beta_{DM} > 0 \\ \frac{\partial \beta_{DM}}{\partial ROE} = -0.001 < 0 \end{cases} \qquad (15)$$

The above formula infers that competitive pressure in the product market positively modulates the level of the effect of monetary policy on enterprises' R&D investment. Compared with enterprises with low competitive pressure in the product market, enterprises with highly competitive pressure show more incentives for R&D, have higher levels of R&D investment and investment density, and exhibit more susceptibility to the effect of monetary policy. In other words, while reinforcing the incentive effect of loose monetary policy shocks on enterprises' R&D investment, it also amplifies the negative effect of tight monetary policy shocks on enterprises' R&D investment. So far, hypothesis 2 has been verified.

Table 4. The role of product market competition

Dependent variable	(1)	(2)	(3)
ROE	-0.025***	-0.008***	-0.008***
	(3.00)	(-4.97)	(-5.33)
R	-0.003***		
	(-8.36)		
M		1.8e-08***	
		(8.13)	
DM			0.001***
			(8.24)
MP*ROE	0.002**	-2.67e-08*	-0.001*
	(1.97)	(-1.67)	(-1.68)
Grow	0.919***	0.917***	0.917***
	(30.97)	(34.58)	(34.09)
Size	-0.025***	-0.008***	-0.008***
	(3.00)	(-4.97)	(-5.33)
Age	-0.003***		
	(-8.36)		
Cf		1.8e-08***	
		(8.13)	
_cons			0.001***
			(8.24)
Firm controls	YES	YES	YES
Industry controls	YES	YES	YES
Adj-R2	0.63	0.63	0.63

Note. t statistics in parentheses, * p<0.01, ** p<0.01, *** p<0.01.

4.2 Robustness

To ensure the reliability of the empirical findings: (a) In the present study, several monetary policy proxies (e.g., the real lending rate) are employed in the empirical test. The tested results of the mentioned variables are listed in columns Table 3 and Table 4, and the net investment in open market operations (MP) and the monetary policy dummy variable (DM) noticeably impact the enterprise's R&D investment density. Moreover, the cross term consisting of the policy variable and the return on net assets (ROE) is significant, and the economic meaning represented by the coefficient symbols of the cross term can be identical to that of the real lending rate (R). The conclusions remain consistent. (b) In the present study, the model is tested again by exploiting the patent data of the sample enterprises, instead of R&D investment density. As indicated from the tested results (Table 5), the real loan interest rate (R) and return on equity (ROE) noticeably impact the number of patents, while the direction of the effect of the critical variables complies with the results of the benchmark regression. (c) As impacted by the potential endogeneity problem of the control variables, all the control variables are regressed again with one period lag. As indicated from the tested results (Table 5), the estimated results are substantially consistent with the benchmark results after controlling for potential endogeneity problems.

Table 5. Robustness test

Dependent variable	Number of patents	R&D Investment density	R&D Investment density
ROE	-631.309*	-0.028***	-0.028***
	(-1.79)	(-3.12)	(-3.19)
R	-20.708***	-0.002***	-0.003***
	(-3.21)	(-6.13)	(-6.39)
MP*ROE	107.367**	0.002*	0.003**
	(1.99)	(1.61)	(2.03)
Enterprise-level controls	YES		YES
Lagged Enterprise-level controls		YES	YES
Property Rights and Industry controls	YES	YES	YES
Adj-R2	0.05	0.62	0.63

Note. t statistics in parentheses, * p<0.01, ** p<0.01, *** p<0.01.

5. Conclusions

Determining the effect of macroeconomic policies on micro enterprises has turned out to be a research hotspot in macroeconomics and corporate finance. Conducting macro-micro cross-sectional study can help change the reality that macroeconomic research lacks a micro basis, while enterprises' behavior research lacks macro guidelines. For the enterprises' innovating behavior, the present study investigates the effect of monetary policy on enterprises' R&D investment and how competitive pressures facing enterprises in product markets modify the micro effects of monetary policy. To determine the moderating effect of competitive pressures on the effect of monetary policy, product market competition and monetary policy related variables are presented by complying with the Aghion et al. (2012) model, and the relationship between monetary policy shocks, competition, and enterprises' R&D investment is determined by solving the problem of maximizing enterprises' return on investment under constraints, and then hypotheses are proposed. To validate the hypothesis, the present study uses the data of listed companies from 2013-2018 as a sample and conducts an empirical analysis using a fixed effects model. As revealed from the analyzed results, monetary policy and product market competition pressure significantly boost enterprises' R&D investment; product market competition has a moderating effect on the effect of monetary policy, and the greater the competitive pressure, the more sensitive the enterprises' R&D investment is to monetary policy.

As the economic development accesses into the new normal, enhancing the capability of independent innovation and improving the quality of the economy have become two vital objectives of China's policy regulation. As highlighted by the findings of the present study, when monetary policy is being formulated and implemented, the heterogeneity of the policy response to the innovating activities of enterprises in different competitive environments should be fully considered. To be specific, when monetary policy is being strengthened, structural policy tools can be employed flexibly to provide the necessary liquidity for well-managed, whereas they can impose competitive pressures to weaken the adverse effect of the policy; during monetary policy easing, the excessive liquidity injection to enterprises with monopoly positions should be avoid. Besides, it is required to deepen market reforms continuously, promote equal market status among enterprises holding different property rights, activate innovative activities of enterprises by elevating the degree of competition, as well as improve the sensitivity of microenterprises to monetary policy to enhance the efficacy of regulatory policies.

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