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Financial market imperfections and sensitivity of cash holdings to R&D investment: Evidence from chinese listed firms☆,☆☆

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ABSTRACT

Previous studies on developed economies have shown that firms with more research and development (R&D) activities tend to hold more cash. In a transitional economy, such as China, where financial market imperfections prevail, the likelihood of firms reserving cash for R&D is even higher. This study identifies two alternative credit financing channels, equity state-ownership and bank connection, that can be used by Chinese listed firms to raise external funds and mitigate the market imperfection problem. Typical external financing facilitation channels (EFFCs) effectively mitigate financial constraints through reducing information asymmetry between firms and creditors, alleviating R&D dependence on cash holdings. However, as China's financial reform deepens, market environment improvement weakens the EFFC effect. Hence, this study deliberates on the mechanisms by which the EFFC effect may be reduced, leading to useful policy implications for financial market reform in China to abate innovation costs.

1. Introduction

How to encourage firms to invest in research and development (R&D) has been debated in the literature. R&D investment faces significant external financing constraints owing to information asymmetry and high uncertainty, which explains why cash reserves are important (Szalay, 2010). Although a large body of research has shown that cash holdings are very sensitive to R&D investment (Bates et al., 2009; Brown and Petersen, 2011; He and Wintoki, 2016), much less has been discussed regarding liquidity management for corporate innovation in developing markets.

In a transitional economy with an imperfect financial market, such as China, serious external financing frictions aggravate corporate R&D dependence on cash holdings. Despite the development of domestic stock markets, bank loans remain the main source of external financing for Chinese firms' R&D (Yao et al., 2018). Banks are influenced by various factors when allocating credit and show obvious structural preferences. Credit-rationing preference is not only a reflection of financial market imperfections but also a special external financing facilitation channel (EFFC) itself, as firms wish to partially overcome market imperfections, which, in turn, affects the relationship between cash holdings and R&D.

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Equity state-ownership and bank connections are two important EFFCs in debt financing for Chinese firms. Equity state-ownership may help obtain implicit government guarantees, and bankers have less screening costs and responsibilities to state-connected firms. When faced with budget constraints on R&D, state-owned enterprises (SOEs) are more likely to obtain funds through formal financial institutions, thereby reducing their need for cash reserves. Bank connections can promote information sharing between related parties, which helps banks reduce their concerns about firms' moral hazards caused by information asymmetry. It can also send a positive signal to the market, which is regarded as a guarantee of financing. Wang et al. (2020) found that equity associations between banks and firms reduce default risk. It is helpful for firms to enjoy lower financing costs and more favorable loan conditions (Lu, 2012). Consequently, bank connections may facilitate corporate debt financing and reduce the dependence of R&D on internal funds. Therefore, this study identifies these two EFFCs, equity state-ownership and bank connections, to answer the first research question: How is the impact of R&D activities on cash holdings affected by EFFCs under financial market imperfections?

The effects of EFFCs on cash-R&D sensitivity may change as the financial environment shifts. As Claessens and Laeven (2003) point out, financial deepening enables firms to use more external financing for R&D. China's financial system is still developing and relatively less efficient in resource allocation than that prevailing in developed countries. In addition, further deregulation of the banking sector is important for reducing the monopolistic power enjoyed by large state-owned banks and releasing more credit supply to support R&D, especially for private firms. Therefore, financial deepening and banking marketization will eventually influence financial market efficiency and the role of EFFCs. Thus, this study aims to answer the second research question: How does financial reform influence the role of EFFCs in cash-R&D sensitivity in the Chinese context?

We use a panel data set covering all Chinese A-share listed firms from 2007 to 2018 and build an econometric model to test our hypotheses. As the two EFFCs, state-ownership and bank connections, are the main research interests, and we define them according to the nature of firms' actual equity controllers and firms' equity and personnel connections with banks. We find that as far as R&D is concerned, firms tend to hold more cash owing to external financing constraints. However, the positive relationship between cash holdings and R&D is significantly influenced by the EFFCs. Specifically, equity state-ownership and bank connections help firms alleviate external financing constraints. Furthermore, we divide the data into subsamples based on the level of national financial deepening and regional bank competition. It indicates that both financial deepening and competition increase market efficiency, reduce costs, and mitigate financing constraints on corporate innovation activities, thus weakening the role of EFFCs in the sensitivity of cash holdings reserved for R&D.

This study makes several contributions to the extant literature. First, existing research on financial constraints on R&D investment analyzes the phenomenon and reason for cash-R&D sensitivity without considering market conditions and channels that ease sensitivity (Brown et al., 2009; Brown and Petersen, 2011). A few studies on the factors influencing cash-R&D sensitivity emphasize innovation activity signaling (Levitas and McFadyen, 2009), industry competitiveness (He and Wintoki, 2016), and firm maturity (Machokoto and Areneke, 2020), but do not pay much attention to the role of external financial environment in financing constraints on R&D activities and the nexus of cash-R&D. To fill this research gap, we explore EFFCs' influence on this sensitivity in an imperfect market environment and find that state-ownership and bank connections reduce corporate cash holdings for R&D purposes in terms of credit-rationing preference.

Second, we provide novel evidence on the importance of credit market reform in corporate R&D from the perspective of credit financial deepening and regional banking competition. In contrast, previous studies on financial market reform and technological innovation emphasize the significance of the equity market (Brown et al., 2009; Hsu et al., 2014) because of risk tolerance (Fang et al., 2014; Moshirian et al., 2021), whereas the impact of the credit market remains controversial (Amore et al., 2013; Hsu et al., 2014; Cornaggia et al., 2015). This study offers new insights into the effects of credit market conditions on R&D and cash reserve management from the perspective of liquidity management with technological innovation. To the best of our knowledge, this study is the first to demonstrate the impact of credit market reform on EFFCs' role in cash-R&D sensitivity.

Finally, we reveal the mechanism of the EFFC effect, showing that EFFCs help firms borrow bank credit and reduce their cash holdings for R&D. Our findings add new evidence from China's developing financial markets to the literature on the relationship between cash holdings and R&D (Brown and Petersen, 2015; Machokoto and Areneke, 2020; Ma et al., 2020).

The remainder of this paper is organized as follows. Section 2 reviews extant literature and develops our hypotheses. Section 3 outlines the study design and defines the variables used in the empirical models. Section 4 discusses the regression results. Section 5 presents the robustness tests. Section 6 examines the mechanism of the EFFC effect on the relationship between cash holdings and R&D. Section 7 concludes.

2. Literature review and hypothesis development

2.1. Literature review

The sensitivity of cash holdings to R&D investment is generated by the particular nature of R&D and its external financing constraints. Compared to other investments, R&D investments must bear higher risk and costs. Holmstrom (1989) suggests that R&D projects are long-term and unpredictable, and the probability of failure is high. R&D outputs are normally intangible and have low collateral value (Brown et al., 2009). Thus, R&D activities face greater external financing constraints (Hsu et al., 2014). Moreover, to protect business secrets, firms are reluctant to disclose R&D information, leading to information asymmetry between potential investors and firms (Bhattacharya and Ritter, 1983), making internal financing more preferable to external sources (Myers and Majluf, 1984; Hall, 2002). Internal funds primarily include operating cash flows and corporate cash reserves. Many studies show that the high volatility of operating cash flows causes instability in R&D investments (Fazzari et al., 1988; Hottenrott and Peters, 2012; Cinceram

et al., 2016). Technological innovation is mostly irreversible and, once interrupted, may incur high adjustment costs (Brown and Petersen, 2011). High liquidity and elasticity of cash reserves can effectively mitigate the impact of operating cash flow fluctuations on technological innovation (Almeida et al., 2004). Consequently, firms tend to increase cash reserves as a buffer to smooth R&D, resulting in higher costs because of lower returns on liquid assets (Opler et al., 1999). Based on the cash holdings model developed by Opler et al. (1999), Bates et al. (2009) document a dramatic increase in the average cash ratio for U.S. firms during 1980–2006 due to increased R&D expenditures. Brown and Petersen (2011) further examine the implications of an increase in R&D investment for liquidity management and find strong evidence that firms depend heavily on cash reserves to smooth R&D in the U.S. manufacturing industry.

Extant literature on the factors influencing cash-R&D sensitivity mainly focuses on innovation activity signaling, industry competitiveness, and firm maturity. Using a sample of U.S. biotechnology firms, Levitas and McFadyen (2009) conclude that patent production and certain alliance activities provide important signaling mechanisms that lower research-intensive firms' need to hold cash. He and Wintoki (2016) find that increased competitiveness in R&D-intensive industries gives firms increasingly strong incentives to maintain a liquidity buffer to smooth the path of R&D. Machokoto and Areneke (2020) confirm the markedly different maturity and scale of R&D firms in emerging economies relative to those in advanced economies, which affect the reliance on corporate savings to finance innovation. However, most extant studies have not paid sufficient attention to the role of external financial environment in financing constraints on R&D activities, largely neglecting the impact of financial market conditions on cash-R&D nexus.

Extant literature on financial market conditions mainly concentrates on the direct association between financial markets and innovation, emphasizing the significance of equity markets for R&D investment. Focusing on the dramatic 1990s boom in U.S. R&D, Brown et al. (2009) find that shifts in the supply of equity finance can explain a significant portion of the fluctuations in young firms' R&D and suggest paying more attention to equity finance, particularly to models that emphasize innovation. Using a sample of 32 developed and emerging countries, Hsu et al. (2014) conclude that industries that are more dependent on external financing and more high-tech intensive exhibit a higher innovation level in countries with better-developed equity markets, but the development of credit markets appears to discourage innovation in industries with these characteristics.

However, some studies argue that credit markets are indispensable for corporate innovation financing. According to Nanda and Nicholas (2014), bank distress during the Great Depression reduced both the quantity and quality of firms' patents, emphasizing the positive role of credit markets in innovation. Exploiting exogenous variations in banking development arising from the staggered deregulation of banking activities across U.S. states, Amore et al. (2013) and Cornaggia et al. (2015) conclude that de-regulation events have beneficial effects on innovation. Trinugroho et al. (2021) explore the nonlinear relationship between credit market development and innovation output.

The controversy over the impact of credit market development on innovation is likely due to the neglect in the heterogeneity of credit market conditions and the ignorance of the mechanism and channel between the credit market and innovation.The sensitivity of cash holdings to R&D investment reflects a strategic liquidity management decision, and China's developing credit market can provide a context for examining cash reserve management for R&D purposes under changing market conditions. Therefore, we linked China's financial market development with R&D dependence on cash holdings in this study.

2.2. Hypotheses

2.2.1. Financial market imperfection and the effect of EFFCs on cash-R&D sensitivity

An external financing environment may affect the positive correlation between cash holdings and R&D. Fazzari et al. (1988) show that in an imperfect capital market, firms have more financing constraints, making the level of investment lower than optimal and more dependent on internal funds. However, in a transitional economy such as China, there are alternative financing channels for firms to secure external financing to overcome the market imperfection problem (Allena et al., 2005). Despite the rapid development of China's stock market, the banking sector still plays an important role in innovation investments (Zhang and Guo, 2019). The importance of bank loans exceeds that of other informal financing channels (Allen et al., 2005). China's banking sector is largely dominated by the so-called "big four" state-owned commercial banks (SOCBs)[1] (Allena et al., 2005). The credit market is arguably distorted. Banks show an obvious structural preference when allocating credits (Bharath et al., 2009). In an imperfect financial market, this credit-rationing preference acts as a typical EFFC that influences the association between cash holdings and R&D. Equity state-ownership and bank connections are two important EFFCs in debt financing for Chinese firms.

Megginson et al. (2014) find that SOEs have a soft budget constraint syndrome and can count on the government to bail them out in times of financial distress. Specifically, equity state-ownership may provide firms with financing facilities in two ways: by increasing credit availability and reducing debt financing costs. SOCBs favor SOEs for their lending (Chong et al., 2013; Jiang and Yao, 2017). This phenomenon has been observed in other emerging markets (Carvalho, 2014). In addition, Guariglia et al. (2011) argue that SOEs can gain unlimited loans from state-owned banks because of their important role in absorbing surplus labor and helping maintain social stability. Zhang and Guo (2019) show that political connections can help firms access bank loans. For debt financing costs, equity state-ownership can obtain implicit government guarantees, and bankers have fewer screening costs and responsibilities, as well as lower interest charges to state-connected firms compared to non-SOEs (Cong et al., 2019). Briefly, SOEs have better credit financing channels and face smaller external financing constraints, which reduce the sensitivity of cash holdings to R&D. Based on this argument,

[1] The "big four" SOCBs in China are the Industrial and Commercial Bank of China, the Agricultural Bank of China, the Bank of China, and the Construction Bank of China.

we propose the following hypothesis:

H1. . As a typical external financing facilitation channel (EFFC), equity state-ownership can alleviate the sensitivity of cash holdings to R&D investment.

Bank connections are another way for firms to mitigate the bank credit discrimination that exists in an imperfect financial market. The bank-firm relationships not only affect the availability of credit, but also play an important role in mortgage and loan costs (Petersen and Rajan, 1994, 1997). The facility of bank connections mainly manifests in increasing credit availability and reducing debt financing costs. Bharath et al. (2009) point out that firms can borrow 1–2% more from related lenders than firms without such ties. Charumilind et al. (2006) find that bank-connected firms in emerging economies are more likely to obtain more debt with less collateral. On the one hand, bank connections can promote the sharing of information between related parties through certain organizational or contractual arrangements, which helps banks obtain nonpublic information about related firms and enables them to effectively supervise R&D projects to reduce concerns about firms' moral hazard caused by information asymmetry (Bolton et al., 2016; Wang et al., 2020). On the other hand, a bank connection, regarded as a guarantee of financing, can send a positive signal to the market about the reputation of the firms in focus. Non-connected lenders believe that connected banks use information advantages to ensure the quality of their relationship loans; thus, other loans can also be guaranteed, thereby reducing firms' financing costs. Therefore, bank connections facilitate debt financing. Compared with non-bank-connected firms, the cash reserve behavior of bank-connected firms is less affected by R&D. Based on this argument, we propose the following hypothesis:

H2. . As another external financing facilitation channel (EFFC), bank connections can alleviate the sensitivity of cash holdings to R&D investment.

2.2.2. China's financial market development and the effect of EFFCs

However, the aforementioned EFFC effect is subject to a changing financial environment. As derivatives of an imperfect market, EFFCs cannot fundamentally resolve the R&D financing constraints. Only by deepening the reform can the financial market provide better services and reduce innovation costs. Hsu et al. (2014) believe that the most important function of financial markets is overcoming moral hazards and adverse selection problems. Financial sector reform affects the cost of cash shortages (Wu et al., 2012), which in turn affects firms' liquidity management for technological innovation. China is constantly deepening its reforms to improve its financial system and to enable the financial sector to play a more active role in economic development. Since the establishment of a multi-layer financial market in 1998 and with the acceleration of the market-oriented reform of the banking industry, China's financial system has undergone profound changes in the past years (Jiang et al., 2013; Peng et al., 2014). With improvements in the legal, financial, and economic systems, the EFFC effect arising from financial market imperfections gradually weakens.

We focus on two aspects of improving financial environment. The first is the deepening of financial reforms at the national level. Claessens and Laeven (2003) find cross-country evidence that a country's level of financial development affects firms' access to external financing and determines the resources available for investment. Henry (2000) studies 11 developing countries and shows that financial development can reduce financing costs, thereby promoting corporate investment. Generally, a highly deepened credit financial environment can provide better credit financial services for corporate technological innovation and ease financing constraints, thereby reducing corporate R&D dependence on cash reserves. As a result, as national financing continues to deepen, the effect of EFFCs will gradually diminish.

The next aspect concerns regional bank competition. The significance of banking sector development in corporate innovation is that banks can generate soft information such as the long-term prospects of R&D and innovation projects (Campbell et al., 2019), which helps alleviate the financing constraints caused by information asymmetry in the credit market. A main objective of China's deepening financial system reform is to optimize the banking market structure. As intensified competition among banks is a typical exogenous shock, it changes the convenience of external financing for firms. In 2009, the China Banking Regulatory Commission (CBRC) promulgated the bank deregulation of geographical branching restrictions and market entry, which relaxed restrictions on new branches of joint-stock banks and city commercial banks. In 2013, the General Office of the State Council of China issued a guide on financial support for economic structural adjustment, which clearly stated an attempt to establish privately owned banks, financial leasing companies, consumer finance companies, and other financial institutions initiated by private capital. The CBRC officially launched the pilot work for privately owned banks in 2014. The direct economic consequence of the series of reforms was an increasing number of joint-stock and city commercial banks, effectively reducing the monopolistic power of large SOCBs (Tan and Anchor, 2017). Deregulation of the banking industry and increased competition are conducive to improving the financial market's reallocation function (Claessens and Laeven, 2005). With the advancement of market-oriented reform, government intervention in banks' credit allocation decisions has weakened and the distortion of credit allocation in the banking system has been alleviated. Barth et al. (2009) suggest that informal payments for loans are widespread in China, and greater banking competition may reduce lending corruption, which can lower the interest rate and enhance credit availability. Similarly, Chava et al. (2013) study U.S. banking deregulation and find that interstate deregulation lowered entry barriers for out-of-state banks and expanded the scope of banks where firms could borrow, thus reducing banks' bargaining power and corporate debt financing costs. In summary, the intensification of bank competition can significantly reduce firms' external financing constraints and weaken the EFFC effect. Based on this argument, we propose the third hypothesis:

H3. **.** Financial market reforms weaken the external financing facilitation channel (EFFC) effect on cash-R&D sensitivity. Specifically, the external financing facilitation channel (EFFC) effect is weaker in years with higher financial deepening and in areas with higher bank competition.

3. Research design

3.1. Regression model

We extend He and Wintoki's (2016) analysis to EFFCs and use Eqs. (1) and (2) to estimate their effects on cash holdings.

$$Cash_{i,t} = \alpha + \beta_0 R\&D_{i,t-1} + \beta_1 State_{i,t} + \beta_2 State_{i,t} \times R\&D_{i,t-1} + \beta_3 X_{i,t-1} + \mu_j + \theta_m + \gamma_t + \mu_j \times \gamma_t + \theta_m \times \gamma_t + \varepsilon_{i,t} \quad (1)$$

$$Cash_{i,t} = \alpha + \beta_0 R\&D_{i,t-1} + \beta_1 BC_{i,t} + \beta_2 BC_{i,t} \times R\&D_{i,t-1} + \beta_3 X_{i,t-1} + \mu_j + \theta_m + \gamma_t + \mu_j \times \gamma_t + \theta_m \times \gamma_t + \varepsilon_{i,t} \quad (2)$$

where $Cash_{i,t}$ is cash holdings for firm i in year t, $R\&D_{i,t-1}$ is R&D expenditure for firm i in year t-1; and $State_{i,t}$ and $BC_{i,t}$ represent equity state-ownership and bank connections, respectively. The main test variable is the interaction terms between EFFCs and R&D spending ($State_{i,t} \times R\&D_{i,t-1}$ and $BC_{i,t} \times R\&D_{i,t-1}$), and we expect a negative and significant β_2. In He and Wintoki's (2016) model, $R\&D_{i,t-1}$ is taken as the explanatory variable and $Cash_{i,t}$ is the explained variable to test the sensitivity of cash holdings to R&D. A positive coefficient of $R\&D_{i,t-1}$ indicates that firms must hold more cash reserves for each additional unit of R&D investment. Based on their model, we add interaction terms between EFFCs and R&D spending ($State_{i,t} \times R\&D_{i,t-1}$ and $BC_{i,t} \times R\&D_{i,t-1}$) to test the effect of EFFCs on the sensitivity of cash holdings to R&D investment. If β_2 is significantly negative, it indicates that EFFCs can decrease the dependence of R&D on cash holdings. To prevent collinearity, we decentralize the interaction terms.

$X_{i,t-1}$ is a vector of the control variables. Eqs. (1) and (2) include the industry fixed effect (μ_j) and year fixed effect (γ_t). θ_m controls the province fixed effect. During the sample period, China promulgated several policies for various industries and regions, which may have had a dynamic impact on the environment, thus leading to unobserved traits among industries and regions being time-variant. Such time variation is correlated with the regressor—cash holdings—and independent variables, such as R&D investments. Without modeling the time-variant traits, the impact of policy changes will be absorbed into the residual, leading to correlations between the regressors and the residual, resulting in omitted variables and estimation biases. Therefore, referring to Hsu et al. (2014) and Chodorow-Reich et al. (2022), we add the industry-year fixed effect ($\mu_j \times \gamma_t$) and the province-year fixed effect ($\theta_m \times \gamma_t$) to control the unobservable time-varying industrial and provincial heterogeneity. Moreover, to justify the rationality of including both fixed effects and two-way fixed effects in the model, following Imai and Kim (2021), we also implement a weighted fixed-effects estimator to test whether the two-way fixed estimator used in the model is misspecified. $\varepsilon_{i,t}$ is the residual term, and the standard errors are clustered at the firm level.

3.2. Variable measurements

Cash holdings. Following Bates et al. (2009), cash holdings (Cash) are calculated as cash plus short-term investments, divided by the book value of total assets. According to the accounting standards that China issued in 2007, short-term investments are defined as trading financial assets.

R&D investment. R&D investment (R&D) is defined as the ratio of R&D expenditure over total assets (He and Wintoki, 2016). The Chinese Accounting Standards promulgated in 2007 require firms to disclose R&D expenditures, so we set the missing R&D to zero.

EFFCs. The first type is equity state-ownership (State). The sample is divided into SOEs and non-SOEs according to the actual equity controllers of the listed firms. For SOE, State= 1; otherwise, State= 0. The other is bank connections (BC), which include personnel and equity connections. If a firm appoints a former or current manager of a commercial bank as an executive, there is arguably a personnel connection between the firm and bank (Byrd and Mizruchi, 2005). If a firm holds bank ownership or a bank holds ownership of the firm, it is regarded as an equity connection (Lu et al., 2012; Wang et al., 2020). Lu et al. (2012) point out that Chinese regulations regard firms with at least 5% ownership as related parties. Therefore, we define an equity connection as a firm (or bank) holding more than 5% of the other party's equity shares and among the top 10 shareholders of the other party. When the firm and bank have either a personnel connection or an equity connection, BC= 1; otherwise, BC= 0. State and BC are measured annually; therefore, they are time-varying.

Financial deepening. McKinnon (1973) first proposed the ratio of generalized currency supply quantity (M2) to GDP as a measure of the financial development of a country.[2] In China's financial system, banks with currency creation and monetary policy transmission functions have an absolute advantage over other financial intermediaries (Berger et al., 2009). As this study mainly examines the effect of the EFFCs in the credit market, we use M2/GDP as a proxy for financial deepening (Deep), especially credit financial deepening, at the national level.

Additionally, we use the ratio of private credit to GDP as another measure of financial deepening (*Deep*2). Private sector credit is the cornerstone of economic and financial development (Alshubiri et al., 2020). Higher levels of private credit indicate higher levels of financial services and, therefore, greater financial intermediary development (Levine et al., 2000). The ratio of private credit to GDP reflects the actual use of external debt financing in the economy and has been used extensively in the existing literature (Jokivuolle et al., 2015; Desbordes and Wei, 2017; Chauvet and Jacolin, 2017; Ho et al., 2018).

[2] The currency division announced by the People's Bank of China is as follows: M0 = cash in circulation, M1 = M0 + corporate demand deposits, M2 = M1 + quasi-currency, where quasi-currency = term deposit + resident savings deposit + other deposits. As an indicator of the scale of monetary and financial assets, M2 can represent the position of bank financial intermediaries in the national economy.

Bank competition. There are four main measures of banking competition: the Lerner index (Anzoátegui et al., 2012; Horvath et al., 2016; Yin, 2021), the Boone index (Kick and Prieto, 2015; Azmi et al., 2019), the Herfindahl–Hirschman index (Degryse and Ongena, 2007; Zhang et al., 2019; Kong et al., 2022), and the concentration ratio (Chong et al., 2013; Du and Cheng, 2022). The Lerner and Boone indices are constructed based on balance sheet and income statement data, which are available only at the bank level and are not disaggregated by region. They are related to the competition faced by individual banks, rather than competition at the regional banking industry level. Thus, owing to data availability, we use the Herfindahl–Hirschman index and concentration ratio, which are widely used in the existing literature, as proxies for bank competition.

As per Zhang et al. (2019), Ye et al. (2019) and Kong et al. (2022), we use bank branch presence in each province[3] to construct a bank competition proxy with the following equation:

$$HHI_m = \sum_{r=1}^{Nm} (branch_{r,m} \Big/ \sum_{r=1}^{Nm} branch_{r,m})^2 \tag{3}$$

where HHI_m is the Herfindahl–Hirschman index of the banking industry in province m, $branch_{r,m}$ is the number of subbranches in province m opened by commercial bank r, and N_m is the total number of commercial banks in province m. Commercial banks in this study comprise all types of joint-stock, city, and rural commercial banks.

In addition, the market access policy for small and medium-sized commercial bank branches promulgated by China in 2009 and the pilot reform of private banks in 2014 are both designed to increase bank competition through diluting the market concentration of the "big four" SOCBs. Hence, we use an additional proxy of concentration ratio to measure the banking structure, as shown in Eq. (4) (Chong et al., 2013; Du and Cheng, 2022).

$$CR4_m = \sum_{n=1}^{4} (branch_{n,m}) \Big/ \sum_{r=1}^{Nm} branch_{r,m} \tag{4}$$

$CR4_m$ represents the market share of the "big four" SOCBs in province m, and $branch_{n,m}$ is the number of subbranches of the "big four" SOCBs in province m.

We calculate the degree of bank competition for each region in each year using Eqs. (3) and (4), respectively. Both are inverse indicators of bank competition, with values ranging from 0 to 1. The smaller the value, the greater the degree of bank competition.

Control variables. Based on extant studies (Opler et al., 1999; Bates et al., 2009; He and Wintoki, 2016), we control firm characteristics that may affect cash holdings: financial leverage (Lev), negative income dummy (Loss), operating cash flow (CF), capital expenditure (CAPEX), net working capital ratio (NWC), market-to-book ratio (M2B), dividend payment dummy (Dividend), firm size (Size), firm age (Age), and its squared term (Age^2). In addition, Hanlon et al. (2017) show that firms with high R&D levels face higher tax uncertainty and thus hold more cash for precautionary motives. Hence, we use the effective tax rate (ETR) as a proxy for the actual burden of a firm. Chen et al. (2012) find that firms with serious shareholder agency problems tend to hold more cash because of their rent-seeking behavior. For this, we construct a proxy for corporate governance (Monitor) based on the concentration of top 10 shareholder equity. Appendix A summarizes the definitions and calculations of all the variables.

3.3. Sample and descriptive statistics

Sample and data. Our base sample consists of all A-share firms listed on the Shanghai and Shenzhen stock exchanges from 2007 to 2018. Our sample data starts from 2007 rather than an earlier year because the accounting standards clarifying R&D investments were issued in China in 2006 and enforced in 2007. Private credit data are obtained from the World Bank database. Bank branch data are manually collected from the financial license information of the national financial institutions issued by the CBRC. This information includes the names of individual financial institutions, dates of approval of establishment, residence, and dates of issuance of financial licenses. The GDP data come from the relevant annual issues of the Almanac of China's Finance and Banking. Data on non-financial firms' equity in banks are taken from the WIND database. The remaining data come from the CSMAR database,[4] including data on personnel connections between firms and banks. Following the extant literature, we excluded (1) all financial and public utility firms; (2) ST and PT firms; (3) firms with missing related data; (4) firms with negative operating income, negative equity, or negative total assets; and (5) industries with fewer than five annual observations. Our final sample contains 2340 firms with 14,384 firm-year observations. All continuous variables are winsorized at the 1% and 99% levels.

Descriptive statistics. Table 1 shows the summary statistics of all variables for the full sample. The average cash-to-assets ratio (Cash) during the sample period is 0.187, the minimum is 0.003, and the maximum is 0.720, indicating a large difference in the level of cash holdings of different firms. The mean value of the R&D-to-assets ratio (R&D) is 0.012, which is lower than that of U.S. firms (0.043), as reported by He and Wintoki (2016), indicating that Chinese firms' R&D investment is relatively low. SOEs account for 44.9% of all firms and bank-connected firms account for 21.7%. The average HHI of provinces' commercial banks is 0.082, and the

[3] The data of bank loan amounts are not available at the provincial level. We cannot use them to calculate the indicator of regional bank competition.

[4] The CSMAR (China Securities Market and Accounting Research) database is jointly produced by GTA Information Technology Co., Ltd. of Hong Kong University and China Accounting and Financial Research Center of Hong Kong Polytechnic University, which is developed in accordance with CRSP, COMPUSTAT and other database construction standards. The database was used by Wu et al. (2012), Chen et al. (2012), Megginson et al. (2014) in our references.

Table 1
Summary statistics.

Variables	N	Mean	Std.	Min	P25	P50	P75	Max
Cash	14,384	0.187	0.153	0.003	0.079	0.141	0.249	0.720
R&D	14,384	0.012	0.017	0.000	0.000	0.001	0.020	0.086
BC	14,384	0.217	0.413	0.000	0.000	0.000	0.000	1.000
State	14,384	0.449	0.497	0.000	0.000	0.000	1.000	1.000
Lev	14,384	0.405	0.217	0.022	0.229	0.400	0.573	0.884
Loss	14,384	0.103	0.304	0.000	0.000	0.000	0.000	1.000
CF	14,384	0.035	0.077	-0.197	-0.005	0.033	0.078	0.258
CAPEX	14,384	0.043	0.048	0.000	0.007	0.026	0.062	0.224
NWC	14,384	0.009	0.200	-0.521	-0.118	0.019	0.145	0.496
M2B	14,384	0.910	0.848	0.087	0.380	0.632	1.098	4.651
Dividend	14,384	0.713	0.452	0.000	0.000	1.000	1.000	1.000
Size	14,384	21.780	1.286	19.370	20.850	21.580	22.490	25.840
Monitor	14,384	0.178	0.121	0.014	0.083	0.151	0.248	0.575
ETR	14,384	0.172	0.158	-0.512	0.113	0.161	0.243	0.766
Age	14,384	2.621	0.429	0.000	2.398	2.708	2.890	3.871
Age^2	14,384	7.055	2.059	0.000	5.750	7.334	8.354	14.990
HHI	14,384	0.082	0.028	0.034	0.064	0.079	0.097	0.176
CR4	14,384	0.491	0.096	0.316	0.414	0.497	0.557	0.763
Deep	14,384	1.819	0.168	1.487	1.740	1.803	1.907	2.085
Deep2	14,384	133.859	14.432	102.004	124.408	134.319	140.237	157.812
IR	14,384	0.012	0.037	0.000	0.000	0.002	0.007	0.280
Collateral	14,384	0.191	0.279	0.000	0.000	0.042	0.290	1.000

Note: This table reports the descriptive statistics of the variables for the entire sample. Appendix A presents definitions of the variables. The above values are all decimals and not percentages.

market share of the "big four" SOCBs (CR4) is 0.491, indicating that China's banking market is still dominated by the "big four."

Table 2 presents the descriptive statistics and difference-in-means tests for the subsamples of firms with different EFFCs. In Panel A, SOEs differ significantly from non-SOEs for all variables. The *Cash* of non-SOEs is 21.6%, 6.5% higher than that of SOEs, indicating that non-SOEs are more likely to hold large amounts of cash. The *R&D* of non-SOEs is 0.016, which is significantly higher than that of SOEs. Moreover, the average *Lev* of non-SOEs is significantly lower than that of SOEs, indicating that SOEs find it easier to secure debt financing.

Panel B shows that cash holdings and R&D levels of non-bank-connected firms are significantly higher than those of bank-connected firms, whereas the leverage ratio is significantly lower. The results of the difference-in-means test show that the two EFFCs may affect the relationship between cash holdings and R&D, although this needs to be further tested using a formal econometric approach.

3.3.1. Analysis of correlation coefficients

Appendix C presents the Pearson and Spearman correlation results for the main variables. There is a significant positive correlation between *Cash* and *R&D* at the 1% level, indicating that R&D activities face significant financial constraints. We also find that both *BC* and *State* are negatively and significantly correlated with *Cash* at the 1% level. This relationship suggests that firms with state-ownership or bank connections have lower cash reserves. Meanwhile, most of the absolute values of the correlations are below 0.5, indicating that the strong multicollinearity among the variables is not a serious concern.

3.3.2. Analysis of variance inflation factor

Appendix C presents the variance inflation factor (VIF) values. The absence of multicollinearity in our estimated models is further indicated by the fact that the VIF values are below the suggested cutoff of 10.

4. Empirical results and analysis

4.1. Baseline regression

The regression results based on Eqs. (1) and (2) are presented in Table 3. In column (1), the coefficient of R&D lagged by one period on current cash holdings is 0.475, which is significant at the 1% level, indicating that more R&D-intensive firms tend to reserve more cash.

The results in columns (2)–(5) reflect the role of EFFCs in cash-R&D sensitivity. For equity state-ownership, the coefficient of *State*×*R&D* is − 0.425, which is significant at the 5% level (column 2), implying that the marginal effect coefficient of R&D on cash holdings is 0.291 (i.e., 0.716–0.425) for SOEs and 0.716 for non-SOEs. SOEs require only 0.291 yuan in cash reserves for every yuan of R&D investment, whereas non-SOEs require 0.716 yuan. After controlling for industry-year and province-year fixed effects, the coefficient of *State*×*R&D* (column 3) remains negative and significant. Overall, equity state-ownership moderates the sensitivity of corporate cash holdings to R&D investment.

Table 2
Mean-difference tests between subsamples.

Panel A: T-test by *State*					
	***State*=0**		***State*=1**		
Variables	**Mean**	**N**	**Mean**	**N**	**Diff.**
Cash	0.216	7665	0.151	6719	0.065***
R&D	0.016	7665	0.007	6719	0.009***
Lev	0.349	7665	0.469	6719	-0.119***
Loss	0.083	7665	0.125	6719	-0.041***
CF	0.034	7665	0.036	6719	-0.003**
CAPEX	0.047	7665	0.038	6719	0.009***
NWC	0.056	7665	-0.045	6719	0.101***
M2B	0.689	7665	1.163	6719	-0.474***
Dividend	0.754	7665	0.665	6719	0.089***
Size	21.411	7665	22.199	6719	-0.787***
Monitor	0.161	7665	0.197	6719	-0.036***
ETR	0.163	7665	0.182	6719	-0.019***
Age	2.556	7665	2.696	6719	-0.140***
Age^2	6.749	7665	7.405	6719	-0.656***
Panel B: T-test by *BC*					
	***BC*=0**		***BC*=1**		
Variables	**Mean**	**N**	**Mean**	**N**	**Diff.**
Cash	0.191	10988	0.173	3396	0.018***
R&D	0.013	10988	0.010	3396	0.003***
Lev	0.395	10988	0.438	3396	-0.043***
Loss	0.103	10988	0.103	3396	-0.000
CF	0.035	10988	0.034	3396	0.001
CAPEX	0.043	10988	0.040	3396	0.003***
NWC	0.018	10988	-0.020	3396	0.038***
M2B	0.848	10988	1.113	3396	-0.266***
Dividend	0.709	10988	0.725	3396	-0.015*
Size	21.663	10988	22.153	3396	-0.490***
Monitor	0.173	10988	0.194	3396	-0.021***
ETR	0.171	10988	0.177	3396	-0.006**
Age	2.622	10988	2.618	3396	0.004
Age^2	7.059	10988	7.043	3396	0.016

Note: Panel A reports the descriptive statistics of the relevant variables for the non-SOE (*State*=0) and SOE (*State*=1) subsamples. Panel B reports the descriptive statistics of the relevant variables for subsamples of non-bank-connected (*BC*=0) and bank-connected firms (*BC*=1). The last column shows the results of the mean-difference test. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

As for bank connections, the coefficient of $BC \times R\&D$ is − 0.520 (column 4), which is significant at the 5% level. The coefficient of R&D investment of bank-connected firms on cash holdings is only 0.058 (i.e., 0.578–0.520) and that of non-bank-connected firms is 0.578. Every yuan of R&D investment in a bank-connected firm only increases cash reserves by 0.058 yuan, whereas non-bank-connected firms need to increase cash reserves by 0.578 yuan. The coefficient of $BC \times R\&D$ is − 0.615 (column 5), which is statistically significant at the 1% level, indicating that, after controlling for time-varying industry and province characteristics, bank connections can still significantly alleviate the sensitivity of cash holdings to R&D. These regression results support Hypotheses 1 and 2.

The regression results for the control variables are similar to those found in other studies (Opler et al., 1999; Bates et al., 2009). Cash holdings are negatively associated with the leverage ratio (*Lev*), operating loss (*Loss*), market-to-book ratio (*M2B*), and firm size (*Size*), but significantly and positively correlated with operating cash flow (*CF*), propensity to pay dividends (*Dividend*), and equity concentration (*Monitor*).

Referring to Imai and Kim (2021), we implement a weighted fixed-effects estimator in the regressions. The results in Appendix B are similar to those in Table 3, suggesting that the two-way fixed estimator used in the model is not misspecified.

4.2. The effect of EFFCs in China's financial market

We conducted several tests on the EFFC effect resulting from national financial deepening and regional banking competition.

The results reported in Table 4 indicate that the EFFC effect of bank connections is significantly weaker in years with higher financial deepening. The results reported in Table 5 show that the EFFC effects of equity state-ownership and bank connections both decrease in areas with higher bank competition. These support Hypothesis 3—that financial market reform weakens the EFFC effect on cash-R&D sensitivity.

First, we test the impact of national financial deepening. Based on the median of *Deep* (*Deep*2), the sample is divided into a lower financial deepening group (Low-fin) and a higher financial deepening group (High-fin). In Panel A of Table 4, the coefficient of $BC \times R\&D$ is − 1.127 (column 3), which is significant at the 1% level. The same coefficient is insignificant in column (4), indicating that bank connections reveal the EFFC effect only when the national financial depth is low, and this effect is weakened when the financial environment improves.

Table 3
EFFC effect on the cash-R&D sensitivity.

Variables	(1)	(2)	(3)	(4)	(5)
R&D	0.475 * **	0.716 * **	0.677 * **	0.578 * **	0.768 * **
	(3.933)	(4.551)	(4.159)	(4.518)	(5.810)
State		-0.002	-0.003		
		(−0.389)	(−0.752)		
State×R&D		-0.425 * *	-0.357 *		
		(−2.039)	(−1.663)		
BC				-0.004	-0.002
				(−1.046)	(−0.583)
BC×R&D				-0.520 * *	-0.615 * **
				(−2.362)	(−2.712)
Lev	-0.202 * **	-0.159 * **	-0.158 * **	-0.202 * **	-0.215 * **
	(−15.881)	(−14.167)	(−13.969)	(−15.893)	(−16.582)
Loss	-0.015 * **	-0.026 * **	-0.027 * **	-0.015 * **	-0.014 * **
	(−3.638)	(−6.397)	(−6.423)	(−3.594)	(−3.283)
CF	0.157 * **	0.157 * **	0.151 * **	0.156 * **	0.151 * **
	(8.247)	(8.231)	(7.924)	(8.241)	(7.954)
CAPEX	-0.346 * **	-0.264 * **	-0.263 * **	-0.347 * **	-0.353 * **
	(−11.696)	(−9.050)	(−8.819)	(−11.752)	(−11.668)
NWC	-0.117 * **	-0.117 * **	-0.129 * **	-0.117 * **	-0.129 * **
	(−9.872)	(−9.892)	(−10.717)	(−9.903)	(−10.717)
M2B	-0.009 * **	-0.011 * **	-0.011 * **	-0.009 * **	-0.010 * **
	(−3.866)	(−4.281)	(−4.177)	(−3.976)	(−3.988)
Dividend	0.028 * **	0.028 * **	0.026 * **	0.028 * **	0.026 * **
	(8.389)	(8.349)	(7.747)	(8.394)	(7.787)
Size	-0.006 * **	-0.002	-0.002	-0.005 * **	-0.006 * **
	(−2.784)	(−0.895)	(−1.137)	(−2.635)	(−2.664)
Monitor	0.033 * *	0.048 * **	0.045 * **	0.032 * *	0.031 *
	(2.083)	(2.963)	(2.759)	(2.061)	(1.917)
ETR	-0.010	-0.009	-0.008	-0.010	-0.009
	(−1.449)	(−1.270)	(−1.102)	(−1.457)	(−1.233)
Age	-0.105 * **	-0.112 * **	-0.096 * **	-0.106 * **	-0.078 * **
	(−3.836)	(−3.928)	(−3.369)	(−3.878)	(−2.841)
Age^2	0.016 * **	0.019 * **	0.016 * **	0.016 * **	0.011 *
	(2.827)	(3.129)	(2.612)	(2.867)	(1.914)
Constant	0.469 * **	0.393 * **	0.366 * **	0.467 * **	0.417 * **
	(8.491)	(6.952)	(6.241)	(8.431)	(6.545)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	No	No	Yes	No	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Province-Year FE	No	No	Yes	No	Yes
Observations	14,384	14,384	14,384	14,384	14,384
Adjusted R^2	0.258	0.214	0.226	0.258	0.269

Note: The dependent variable in all regressions is *Cash*. Column (1) tests the sensitivity of cash holdings-R&D, columns (2) and (3) test the EFFC effect of equity state-ownership, and the last two columns test that of bank connections. The *t*-values in parentheses are based on robust standard errors clustered at firm level. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

In column (3), the coefficient of *BC×R&D* is − 1.127, while the coefficient of *R&D* is 0.815. The absolute value of the former is greater than that of the latter, indicating that in the Low-fin group, each additional unit of R&D investment of firms connected with banks leads to a decline in cash holdings of 0.312 yuan (i.e. 0.815–1.127). This may be because R&D investment directly consumes cash reserves and bank-connected firms are not in a rush to replenish such reserves after R&D investment thanks to high credit availability. In the short term, R&D investment seems to reduce cash holdings in bank-connected firms when financial deepening level is low.

In general, financial deepening at the national level has a less powerful impact on financing facilities based on equity state-ownership than on bank connections, as the coefficients of *State×R&D* (columns 1 and 2) are statistically insignificant.

The results in Panel B, where financial deepening is measured by the private credit to GDP ratio, are consistent with those in Panel A, where financial deepening is measured by the M2 to GDP ratio.

We further analyze the impact of bank competition on the EFFC effect. The results are presented in Table 5. The sample is grouped according to the degree of regional bank competition[5] (*HHI* and *CR*4). Both indicators are reverse indicators, so *HHI* (or *CR*4) higher than the annual median is the group with lower bank competition (Low-com); otherwise, it has higher competition (High-com). Panel A presents the subsample regression results based on *HHI* and Panel B presents the results based on *CR*4.

[5] The firm location is defined by a firm's office address in CSMAR database.

Table 4
National financial deepening and EFFC effects.

	Panel A: Financial deepening measured by M2/GDP				Panel B: Financial deepening measured by private credit/GDP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Low- fin	High-fin	Low-fin	High-fin	Low-fin	High-fin	Low-fin	High-fin
R&D	0.712 * **	0.732 * **	0.815 * **	0.738 * **	0.631 * *	0.768 * **	0.795 * **	0.773 * **
	(3.303)	(3.999)	(4.263)	(4.774)	(2.546)	(4.576)	(3.713)	(5.391)
State	-0.008	-0.002			-0.003	-0.006		
	(−1.474)	(−0.348)			(−0.536)	(−1.256)		
State×R&D	-0.400	-0.127			-0.312	-0.185		
	(−1.235)	(−0.548)			(−0.906)	(−0.832)		
BC			-0.004	0.000			-0.004	-0.001
			(−0.851)	(0.077)			(−0.683)	(−0.184)
BC×R&D			-1.127 * **	-0.271			-1.262 * **	-0.358
			(−3.798)	(−0.913)			(−3.840)	(−1.312)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6967	7417	6967	7417	5115	9269	5115	9269
Adjusted R^2	0.304	0.242	0.305	0.242	0.266	0.270	0.268	0.270

Note: The dependent variable in all regressions is *Cash*. The *t*-values in parentheses are based on robust standard errors clustered at firm level. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5
Bank competition and EFFC effect.

	Panel A: Bank competition measured by *HHI*				Panel B: Bank competition measured by *CR4*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Low-com	High-com	Low-com	High-com	Low-com	High-com	Low-com	High-com
R&D	1.058 * **	0.482 * *	1.022 * **	0.570 * **	1.043 * **	0.442 * *	1.034 * **	0.527 * **
	(4.383)	(2.382)	(5.011)	(3.358)	(4.649)	(2.197)	(5.324)	(3.068)
State	0.000	-0.007			0.001	-0.008		
	(0.066)	(−1.216)			(0.243)	(−1.370)		
State×R&D	-0.530 *	0.003			-0.516 *	0.062		
	(−1.731)	(0.011)			(−1.753)	(0.219)		
BC			-0.009	0.004			-0.009	0.004
			(−1.432)	(0.822)			(−1.528)	(0.948)
BC×R&D			-0.865 * *	-0.431			-0.898 * **	-0.328
			(−2.569)	(−1.437)			(−2.825)	(−1.117)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6265	8119	6265	8119	6701	7683	6701	7683
Adjusted R^2	0.282	0.257	0.283	0.257	0.284	0.254	0.286	0.254

Note: The dependent variable in all regressions is *Cash*. Panel A is grouped based on *HHI*, and Panel B is grouped based on *CR4*. The *t*-values in parentheses are based on robust standard errors clustered at firm level. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

In the Low-com group (columns 1 and 5) of Table 5, the coefficients of *State×R&D* are.

-0.530 and − 0.516, respectively, both of which are significant at the 10% level. However, those in the High-com group are insignificant (columns 2 and 6). Bank-connected firms show similar regression results. The absolute values and significance levels of the *BC×R&D* coefficients in columns (3) and (7) are greater than those in columns (4) and (8). This implies that the EFFC effects are only significant when bank competition is low. As bank competition intensifies, an increase in the regional credit supply weakens the EFFC effects. These results also support Hypothesis 3.

5. Robustness tests

A reverse (or simultaneous) causal relationship may exist between corporate cash holdings and R&D. Firms' cash holding behavior for R&D may be guided toward maintaining financial flexibility rather than a passive action affected by external financing constraints. This may lead us to misinterpret the relationship between cash holdings and R&D as well as the EFFC effect on the cash-R&D nexus.

Therefore, we use the IV-GMM to solve the problem of reverse causality, following Mishra and Mishra (2012) and Zakari et al. (2022). Motivated by Fisman and Svensson (2007), we use the one-year lagged R&D mean of industry-province, where a firm is located, as an instrumental variable (IV) and the generalized method of moments (GMM) for estimation.[6] First, we test for endogeneity in *R&D*. The results show that the DWH statistic is 52.47, which is significant at the 1% level (not reported to save space). This finding indicates that the original model may have had endogeneity issues. We then test the correlation between the IV and endogenous variables (*R&D*). The *F*-statistic corresponding to the first-stage regression is 2209.12, and the *p*-value is 0.000, indicating that there is no problem of a weak IV.

Tables 6 and 7 show the IV-GMM regression results based on equity state-ownership and bank connections, respectively. Column (1) of Table 6 shows that equity state-ownership significantly alleviates the sensitivity of cash holdings to R&D. Columns (2)–(5) show that, when the degree of national financial deepening is high, the EFFC effect of equity state-ownership weakens or even disappears. The regression results for bank connections are listed in Table 7. Column (1) of Table 7 indicates that bank connections significantly alleviate cash-R&D sensitivity. Columns (4) and (5) demonstrate that when financial deepening is high, the EFFC effect of bank connections disappears. Columns (8) and (9) show that when bank competition is fierce, the EFFC effect of bank connections becomes insignificant.

The above analysis shows that the main conclusions of our study are not significantly affected by the IV-GMM estimation.

6. Further analysis: the mechanism of alleviating financing constraints

Here, we test the channel mechanism of EFFCs to ease financing constraints: credit availability and debt financing costs.

6.1. Credit availability

The Chinese banking system is dominated by large SOCBs that provide relaxed credit conditions and support for SOEs based on property rights (Firth et al., 2009). At the same time, compared with non-bank-connected firms, bank-connected firms are more likely to obtain relationship loans from connected banks. Some studies use the leverage ratio to measure enterprises' credit availability; however, using this indicator alone may underestimate their true ability to obtain credit (Petersen and Rajan, 1997). This is because a firm's lower debt level may be due to its unwillingness to use debt financing. We combine the collateral-to-debt ratio (*Collateral*) with the leverage ratio (*Lev*) to comprehensively judge the availability of credit.[7] If a firm's leverage ratio is above the industry-year median and its collateral-to-debt ratio is below the industry-year median, the firm can obtain more credit with more relaxed loan conditions and is classified in the group with higher credit availability. Otherwise, it is placed in the group with lower credit availability. *Creditava* is a dummy variable used to measure the credit availability. Firms with higher credit availability in a given year are assigned a value of 1; otherwise 0.

To examine the working channel effect of credit availability, we construct three-way interactions, as shown in Eqs. (5) and (6), and the results are shown in Table 8. The coefficient of the three-way interaction term (*R&D*×*State*×*Creditava*) is significantly positive (0.884) at the 5% level, as shown in column (1). In column (2), the coefficient of *R&D*×*BC*×*Creditava* is 0.738, significant at the 10% level. This shows that in firms with higher credit availability, the EFFC effect is significantly lower than in those with lower credit availability, and that EFFCs play a role in increasing credit availability when firms face credit constraints, thereby reducing the sensitivity of cash holdings to R&D investment.

$$\begin{aligned}\mathrm{Cash}_{i,t} &= \alpha + \beta_0 R\&D_{i,t-1} + \beta_1 State_{i,t} + \beta_2 State_{i,t} \times R\&D_{i,t-1} + \beta_3 State_{i,t} \times \mathrm{Creditava}_{i,t} \\ &+\beta_4 R\&D_{i,t-1} \times State_{i,t} \times \mathrm{Creditava}_{i,t} + \beta_5 R\&D_{i,t-1} \times \mathrm{Creditava}_{i,t} + \beta_6 \mathrm{Creditava}_{i,t} \\ &+\beta_7 X_{i,t-1} + \mu_j + \theta_m + \gamma_t + \mu_j \times \gamma_t + \theta_m \times \gamma_t + \varepsilon_{i,t}\end{aligned} \tag{5}$$

$$\begin{aligned}\mathrm{Cash}_{i,t} &= \alpha + \beta_0 R\&D_{i,t-1} + \beta_1 BC_{i,t} + \beta_2 BC_{i,t} \times R\&D_{i,t-1} + \beta_3 BC_{i,t} \times \mathrm{Creditava}_{i,t} \\ &+\beta_4 R\&D_{i,t-1} \times BC_{i,t} \times \mathrm{Creditava}_{i,t} + \beta_5 R\&D_{i,t-1} \times \mathrm{Creditava}_{i,t} + \beta_6 \mathrm{Creditava}_{i,t} \\ &+\beta_7 X_{i,t-1} + \mu_j + \theta_m + \gamma_t + \mu_j \times \gamma_t + \theta_m \times \gamma_t + \varepsilon_{i,t}\end{aligned} \tag{6}$$

6.2. Debt financing costs

Corporate R&D investment generally faces information asymmetry, leading to higher cost arising from external financing (Myers and Majluf, 1984). In this section, we combine the loan interest rate (*IR*) and collateral-to-debt ratio (*Collateral*) to judge the cost of debt financing for firms.[8]

Although the cost of debt financing may be directly reflected in the loan interest rate of firms, this rate can be affected by many other factors, such as loan amount and loan duration; therefore, this indicator cannot measure the borrowing cost alone. To reduce the

[6] The GMM is a more effective estimation method when the residual finding of the model has heteroskedasticity or autocorrelation. For the sake of robustness, we also use the two-stage least squares method under the assumption of conditional homoskedasticity and the maximum likelihood estimation method that is insensitive to weak IV. Results show that our main conclusions are not affected by the estimation method.

[7] *Collateral*= Δmortgage loan/Δtotal loans of the firm

[8] *IR* is calculated as current interest expense over loan balance of a firm in year t-1, where loan balance includes short-term, long-term debt, and long-term debt due in the current period from banks.

Table 6
Regression results of IV-GMM for equity state-ownership.

Variables		Group by M2/GDP		Group by private credit/GDP		Group by bank HHI		Group by bank CR4	
	(1) full sample	(2) Low-fin	(3) High-fin	(4) Low-fin	(5) High-fin	(6) Low-com	(7) High-com	(8) Low-com	(9) High-com
R&D	1.002 * **	1.631 * **	1.297 * **	1.359 * **	1.227 * **	0.962 * **	0.770 * *	1.081 * **	0.621 *
	(4.102)	(3.938)	(4.825)	(2.898)	(4.756)	(2.595)	(2.260)	(2.999)	(1.894)
State×*R&D*	-0.672 * *	-1.704 * **	-0.204	-1.289 * *	-0.507 *	-0.589	-0.508	-0.659	-0.389
	(−2.379)	(−3.598)	(−0.666)	(−2.518)	(−1.672)	(−1.440)	(−1.290)	(−1.643)	(−1.024)
State	-0.002	-0.008	0.000	-0.003	-0.004	-0.000	-0.007	0.001	-0.008
	(−0.425)	(−1.503)	(0.088)	(−0.507)	(−0.934)	(−0.030)	(−1.279)	(0.188)	(−1.474)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,384	6967	7417	5115	9269	6265	8119	6701	7683
Adjusted R^2	0.248	0.302	0.229	0.267	0.251	0.272	0.250	0.274	0.247

Note: This table presents the regression results of the IV-GMM for equity state-ownership. The dependent variable is *Cash*, and all the regressions incorporate the full set of controls. The *t*-values in parentheses are based on robust standard errors clustered at firm level. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7
Regression results of IV-GMM for bank connection.

Variables		Group by M2/GDP		Group by private credit/GDP		Group by bank HHI		Group by bank CR4	
	(1) full sample	(2) Low-fin	(3) High-fin	(4) Low-fin	(5) High-fin	(6) Low-com	(7) High-com	(8) Low-com	(9) High-com
R&D	0.856 * **	1.003 * **	1.335 * **	1.161 * **	1.077 * **	0.880 * **	0.674 * **	0.997 * **	0.555 * *
	(4.175)	(3.034)	(5.456)	(3.187)	(4.606)	(2.649)	(2.603)	(3.041)	(2.179)
BC×*R&D*	-0.903 * *	-1.330	-0.662	-1.972 *	-0.622	-1.090	-0.846	-1.216 *	-0.729
	(−2.013)	(−1.350)	(−1.495)	(−1.730)	(−1.381)	(−1.635)	(−1.432)	(−1.902)	(−1.272)
BC	-0.004	-0.005	-0.000	-0.004	-0.002	-0.012 * *	0.003	-0.013 * *	0.004
	(−1.184)	(−0.990)	(−0.090)	(−0.617)	(−0.554)	(−1.976)	(0.692)	(−2.237)	(0.809)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,384	6967	7417	5115	9269	6265	8119	6701	7683
Adjusted R^2	0.248	0.309	0.237	0.236	0.260	0.273	0.251	0.275	0.247

Note: This table presents the IV-GMM regression results for bank connections. The dependent variable is *Cash*, and all the regressions incorporate the full set of controls. The *t*-values in parentheses are based on robust standard errors clustered at firm level. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

adverse selection or moral hazard problems caused by information asymmetry, creditors such as banks require firms to provide collateral (Stiglitz and Weiss, 1981; Jiménez et al., 2006; Menkhoff et al., 2006). Therefore, collateral is regarded as a guaranteed condition of loan. If equity state-ownership and bank connections can alleviate the information asymmetry between firms and creditors, the latter can evaluate the risk types of the former in advance and observe their behavior after obtaining loans more easily, thereby reducing the supervision cost of investment projects. As a result, firms can obtain loans with fewer guaranteed conditions and lower costs, which manifests as a low collateral-to-debt ratio and a low interest rate.

We divide the levels of corporate *IR* and *Collateral* by the industry-year median. Firms with lower *IR* and *Collateral* are defined as the low-cost group; otherwise, they are defined as the high-cost group. *Fcosts* is a dummy variable reflecting debt financing costs that is equal to 1 if a firm is classified in the group with high debt costs in a given year; otherwise 0.

To test the working channel effect of financing costs, we introduce three-way interactions to construct Eqs. (7) and (8), and the results are presented in Table 9. The three-way interaction coefficients of columns (1) and (2) are both significantly negative at the 1% level. The *R&D*×*State*×*Fcosts* coefficient is − 1.089 and the *R&D*×*BC*×*Fcosts* coefficient is − 1.239, indicating that for firms with high debt financing costs, the EFFCs can reduce cash-R&D sensitivity more significantly through low credit costs.

$$\begin{aligned}\mathrm{Cash}_{i,t} = {} & \alpha + \beta_0 R\&D_{i,t-1} + \beta_1 State_{i,t} + \beta_2 State_{i,t} \times R\&D_{i,t-1} + \beta_3 State_{i,t} \times Fcosts_{i,t} \\ & + \beta_4 R\&D_{i,t-1} \times State_{i,t} \times Fcosts_{i,t} + \beta_5 R\&D_{i,t-1} \times Fcosts_{i,t} + \beta_6 Fcosts_{i,t} \\ & + \beta_7 X_{i,t-1} + \mu_j + \theta_m + \gamma_t + \mu_j \times \gamma_t + \theta_m \times \gamma_t + \varepsilon_{i,t}\end{aligned} \tag{7}$$

$$\begin{aligned}\mathrm{Cash}_{i,t} = {} & \alpha + \beta_0 R\&D_{i,t-1} + \beta_1 BC_{i,t} + \beta_2 BC_{i,t} \times R\&D_{i,t-1} + \beta_3 BC_{i,t} \times Fcosts_{i,t} \\ & + \beta_4 R\&D_{i,t-1} \times BC_{i,t} \times Fcosts_{i,t} + \beta_5 R\&D_{i,t-1} \times Fcosts_{i,t} + \beta_6 Fcosts_{i,t} \\ & + \beta_7 X_{i,t-1} + \mu_j + \theta_m + \gamma_t + \mu_j \times \gamma_t + \theta_m \times \gamma_t + \varepsilon_{i,t}\end{aligned} \tag{8}$$

Table 8
Credit availability and EFFC effect.

Variables	(1)	(2)
R&D	0.931 * **	0.924 * **
	(5.578)	(6.374)
State	-0.004	
	(−0.825)	
State×R&D	-0.490 * *	
	(−2.017)	
State×Creditava	0.007	
	(1.019)	
R&D×State×Creditava	0.884 * *	
	(2.472)	
BC		-0.003
		(−0.792)
BC×R&D		-0.724 * **
		(−2.781)
BC×Creditava		-0.003
		(−0.498)
R&D×BC×Creditava		0.738 *
		(1.823)
R&D×Creditava	-1.123 * **	-0.952 * **
	(−3.989)	(−4.377)
Creditava	-0.015 * **	-0.012 * **
	(−3.144)	(−3.634)
Controls	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes
Industry-Year FE	Yes	Yes
Province FE	Yes	Yes
Province-Year FE	Yes	Yes
Observations	14,384	14,384
Adjusted R^2	0.245	0.246

Note: The dependent variable is *Cash*, and all regressions incorporate the full set of controls. The *t*-values in parentheses are based on robust standard errors clustered at firm level. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

7. Conclusion

Using a large data set covering all Chinese listed firms from 2007 to 2018, our study finds strong evidence that R&D activities face significant financial constraints, as manifested by a positive and significant relationship between cash holdings and R&D investments among the sample firms, and that firms employ alternative financing channels to overcome this limitation.

In a transitional economy, such as China, financial market imperfections prevail and present significant challenges to R&D financing. Consequently, firms must seek alternative financing channels, such as equity state-ownership and bank connections (EFFCs), to reduce financing stress and R&D costs. Our empirical results show that, in an imperfect financial market, the two EFFCs can effectively help firms increase credit availability and reduce debt financing costs by reducing information asymmetry between firms and creditors and providing a guarantee for financing. This can alleviate firms' financial constraints and thus reduce the dependence of R&D on cash holdings.

The significant EFFC effect suggests that China's financial markets remain imperfect. Fund accessibility is subject to credit rationing and ownership bias. However, as the financial market reforms deepen, this effect diminishes over the sample period. This study examines two aspects of financial market reform on the EFFC effect: financial deepening and bank competition, both of which mitigate the effect and weaken the sensitivity of cash holdings to R&D investments. They can promote capital allocation efficiency in the financial system and help ease financing constraints on R&D investments. Robustness tests are conducted to ensure that the basic regression results are not spurious.

Our findings enrich emerging literature on financial development and corporate innovation. The empirical results shed light on how to effectively promote the interaction between R&D activities and finance in an emerging economy such as China. Our research also shows that China's financial reform is effective, as reflected by the weakened effect of EFFCs on the R&D–cash holdings nexus. However, the EFFC effect was not entirely eliminated during the sample period, implying that further financial market reform is warranted to promote firms' innovation activities.

This study has several policy implications. The empirical results suggest that reform efforts should be directed toward reducing the monopolistic power of SOCBs and improving market competition by reducing information asymmetry. Only when EFFCs lose their effect on the R&D–cash holdings nexus are we confident that China's financial market is free from market distortion. This is not an easy task and will require further comprehensive reforms to achieve the policy goal, particularly in supporting private enterprises to play a more active role in creating technological innovation in the country. Governments (central and local), financial institutions, and firms

Table 9
Debt financing costs and EFFC effect.

Variables	(1)	(2)
R&D	0.248 *	0.365 *
	(1.745)	(1.756)
State	0.002	
	(0.285)	
State×R&D	-0.483 *	
	(−1.733)	
State×Fcosts	-0.006	
	(−0.836)	
R&D×State×Fcosts	-1.089 * **	
	(−2.754)	
BC		-0.008
		(−1.113)
BC×R&D		-0.419 *
		(−1.746)
BC×Fcosts		0.004
		(0.563)
R&D×BC×Fcosts		-1.239 * **
		(−3.026)
R&D×Fcosts	0.572 * *	0.424 *
	(2.020)	(1.870)
Fcosts	0.009	0.007 *
	(1.625)	(1.697)
Controls	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes
Industry-Year FE	Yes	Yes
Province FE	Yes	Yes
Province-Year FE	Yes	Yes
Observations	14,384	14,384
Adjusted R^2	0.243	0.244

Note: The dependent variable is *Cash*, and all regressions incorporate the full set of controls. The *t*-values in parentheses are based on robust standard errors clustered at firm level. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

must make concerted efforts to achieve this goal. First, governments should deepen financial reforms and continue to guide and regulate the development of commercial banks and other financial institutions to promote effective and fair financial resource allocation. Second, financial intermediaries, which play a key role in credit allocation, need to strengthen both *ex-anti* and *ex-post* supervision of business loans and reduce credit discrimination against private firms, especially small- and medium-sized high-tech enterprises that need to invest heavily in R&D but are often subject to fund shortages. Third, it is imperative for firms to seize opportunities for financial market reform and actively secure various financial resources for R&D investment to improve their market competitiveness.

CRediT authorship contribution statement

Duan Liu: Conceptualization, Formal analysis, Writing – original draft & Review, Secure Funding, Supervision. **Chen Wang:** Data Curation, Methodology, Formal analysis, Writing – original draft. **Hui Zhang:** Formal analysis, Writing – original draft. **Shujie Yao:** Conceptualization, Methodology, Writing – review & editing, Secure Funding. **Zixin Li:** Data Curation, Methodology. All authors were involved in writing the paper and we declare that there is no conflict of interest.

Declaration of Competing Interest

On behalf of all authors, the corresponding author declares that there is no conflict of interest.

Data Availability

Data will be made available on request.

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Appendix A. Variable definitions

Variables	Definitions	Calculations
Dependent variable		
Cash	Cash holdings	(Cash + trading financial assets)/ total assets
Core variables		
R&D	R&D investments	R&D expenditures / total assets
BC	Bank connection	A time-varying dummy variable. Bank connection includes personnel connection and equity connection. If a firm appoints a former or current manager of a commercial bank as an executive, there is a personnel connection. If a firm (or a bank) holds more than 5% of the other party's equity shares and is among the top 10 shareholders of the other party, the firm is regarded as being bank-connected in equity. If a firm is bank-connected in year *t*, BC= 1, otherwise 0.
State	Equity state-ownership	A time-varying dummy variable. If a firm's actual equity controller is the government in year *t*, *State*= 1 (i.e. SOEs), otherwise 0 (i.e. non-SOEs).
Control variables		
Lev	Financial leverage	Total liabilities / total assets
Loss	Negative income	A time-varying dummy variable that equals 1 if a firm suffers negative net profit, and 0 otherwise.
CF	Operating cash flow	Net cash flow from operating activities / total assets
CAPEX	Capital expenditure	The ratio of expenditure for fixed assets, intangible assets and other long-term assets to total assets
NWC	Net working capital	(Current assets - current liabilities - cash - trading financial assets)/ total assets
M2B	Market-to-book ratio	(Market value of equity + book value of liabilities)/ total assets
Dividend	Dividend pay dummy	A time-varying dummy variable that equals 1 if a firm pays dividend, and 0 otherwise.
Size	Firm size	The natural logarithm of total assets
Monitor	Corporate governance	The Herfindahl–Hirschman index of top 10 shareholder equity
ETR	Effective tax rate	Income tax expense/ pre-tax income
Age	Firm age	The natural logarithm of 1 plus firm age
Financial development variables		
HHI	The HHI based on bank branches	$HHI = \sum_{r=1}^{Nm}(branch_{r,m}/\sum_{r=1}^{Nm} branch_{r,m})^2$ in year *t*
*CR*4	The market share based on the "big four" SOCBs' branches	$CR4 = \sum_{n=1}^{4}(branch_{n,m})/\sum_{r=1}^{Nm} branch_{r,m}$ in year *t*
Deep	National financial deepening	M2/GDP
*Deep*2	National financial deepening	Private credit/GDP
Mechanism test variables		
IR	Interest rate	Interest expense in year *t* / loan balance in year *t*-1
Collateral	Collateral-to-debt ratio	Δ mortgage loan/Δ total loan
Creditava	Credit availability	A time-varying dummy variable. If a firm's leverage ratio is above the industry-year median and its collateral-to-debt ratio is below the industry-year median in year t, *Creditava*= 1, otherwise 0.
Fcosts	Debt financing costs	A time-varying dummy variable. If a firm's interest rate and collateral-to-debt ratio are below the industry-year median in year t, *Fcosts*= 0, otherwise 1.

Appendix B. EFFC effect on cash-R&D sensitivity using weighted fixed-effects estimation

Variables	(1)	(2)	(3)	(4)	(5)
R&D	0.594 * **	7.747 * **	0.749 * **	9.159 * **	0.616
	(6.011)	(5.873)	(5.594)	(5.837)	(1.099)
State		-2.399	-0.004		
		(−0.979)	(−1.508)		
State×R&D		-3.895 *	-0.379 *		
		(−2.294)	(−2.176)		
BC				-2.814	-0.003
				(−0.836)	(−0.809)
BC×R&D				-1.360 * **	-1.159 *
				(−3.844)	(−2.325)
Lev	-0.219 * **	-2.190 * **	-0.162 * **	-1.753 * **	-0.183 * **
	(−19.075)	(−19.088)	(−16.792)	(−9.516)	(−6.216)
Loss	-0.018 * **	-1.800 * **	-0.030 * **	-2.380 *	-0.035
	(−3.788)	(−3.822)	(−7.037)	(−2.531)	(−1.110)
CF	0.135 * **	1.344 * **	0.084	1.469 * **	0.143 * *
	(6.832)	(6.819)	(0.235)	(4.080)	(3.202)
CAPEX	-0.366 * **	-3.697 * **	-0.290 * **	-2.989 * **	-0.266 * **
	(−12.395)	(−12.517)	(−1.831)	(−6.898)	(−3.833)
NWC	-0.136 * **	-1.361 * **	-10.251	-1.131 * **	-0.113 * **
	(−12.966)	(−12.991)	(−1.412)	(−5.902)	(−4.766)
M2B	-0.010 * **	-1.012 * **	-0.009 * **	-1.696 * **	-0.017 * **
	(−4.598)	(−4.724)	(−3.989)	(−4.993)	(−4.202)
Dividend	0.030 * **	2.954 * **	0.024	1.964 * *	0.030
	(8.799)	(8.760)	(0.636)	(2.987)	(1.500)
Size	-0.007 * **	-7.157 * **	-0.004 *	-8.422 * *	-0.008 *
	(−4.520)	(−4.446)	(−2.557)	(−2.809)	(−2.240)
Monitor	0.037 * *	3.667 * *	0.052 * **	5.111 *	0.039
	(2.990)	(2.946)	(4.070)	(2.329)	(1.192)
ETR	-0.000	5.032	0.001	-1.367	-0.014
	(−0.012)	(0.006)	(0.110)	(−0.986)	(−0.554)
Age	-0.041	-4.226	-0.050 *	-1.335	0.019
	(−1.754)	(−1.801)	(−2.033)	(−0.187)	(0.190)
Age^2	0.005	4.913	0.007	2.235	-0.005
	(0.963)	(1.018)	(1.395)	(0.162)	(−0.249)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	No	No	Yes	No	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Province-Year FE	No	No	Yes	No	Yes
Observations	14,384	14,384	14,384	14,384	14,384
R^2	0.125	0.125	0.765	0.138	0.702

Note: The dependent variable in all regressions is *Cash*. Column (1) tests the sensitivity of cash holdings-R&D, columns (2) and (3) test the EFFC effect of equity state-ownership, and the last two columns are that of bank connection. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix C. Pearson and Spearman correlation coefficient matrix between the main variables

Variables	*Cash*	*R&D*	*BC*	*State*	*Lev*	*Loss*	*CF*	*CAPEX*	*NWC*	*M2B*	*Dividend*	*Size*	*Monitor*	*ETR*	*Age*
Cash		0.270 * **	-0.046 * **	-0.198 * **	-0.347 * **	-0.175 * **	0.108 * **	0.108 * **	0.173 * **	-0.293 * **	0.232 * **	-0.160 * **	0.031 * **	-0.076 * **	-0.151 * **
R&D	0.227 * **		-0.080 * **	-0.316 * **	-0.244 * **	-0.131 * **	0.084 * **	0.263 * **	0.300 * **	-0.251 * **	0.233 * **	-0.081 * **	-0.029 * **	-0.204 * **	-0.098 * **
BC	-0.050 * **	-0.070 * **		0.062 * **	0.096 * **	-0.012	-0.011	-0.048 * **	-0.080 * **	0.152 * **	0.019 * *	0.165 * **	0.051 * **	0.043 * **	0.020 * **
State	-0.211 * **	-0.251 * **	0.062 * **		0.278 * **	0.070 * **	0	-0.099 * **	-0.273 * **	0.313 * **	-0.097 * **	0.290 * **	0.150 * **	0.100 * **	0.140 * **
Lev	-0.406 * **	-0.238 * **	0.095 * **	0.277 * **		0.157 * **	-0.085 * **	-0.113 * **	-0.546 * **	0.529 * **	-0.186 * **	0.464 * **	-0.001	0.132 * **	0.226 * **
Loss	-0.149 * **	-0.107 * **	-0.012	0.070 * **	0.166 * **		-0.145 * **	-0.140 * **	-0.166 * **	0.071 * **	-0.469 * **	-0.105 * **	-0.090 * **	-0.226 * **	0.061 * **
CF	0.098 * **	0.082 * **	-0.008	0.009	-0.082 * **	-0.129 * **		0.270 * **	-0.131 * **	-0.096 * **	0.161 * **	0.040 * **	0.083 * **	0.040 * **	-0.019 * **
CAPEX	0.01	0.139 * **	-0.026 * **	-0.093 * **	-0.087 * **	-0.105 * **	0.200 * **		-0.024 * **	-0.103 * **	0.169 * **	-0.042 * **	0.070 * **	-0.085 * **	-0.190 * **
NWC	0.122 * **	0.250 * **	-0.074 * **	-0.261 * **	-0.542 * **	-0.179 * **	-0.143 * **	-0.040 * **		-0.321 * **	0.208 * **	-0.216 * **	-0.016 * *	-0.049 * **	-0.105 * **
M2B	-0.258 * **	-0.220 * **	0.156 * **	0.296 * **	0.503 * **	0.081 * **	-0.078 * **	-0.077 * **	-0.263 * **		-0.035 * **	0.548 * **	0.077 * **	0.210 * **	0.162 * **
Dividend	0.206 * **	0.194 * **	0.019 * *	-0.097 * **	-0.195 * **	-0.469 * **	0.142 * **	0.118 * **	0.221 * **	-0.041 * **		0.183 * **	0.151 * **	0.102 * **	-0.101 * **
Size	-0.206 * **	-0.123 * **	0.178 * **	0.299 * **	0.461 * **	-0.099 * **	0.043 * **	-0.039 * **	-0.191 * **	0.539 * **	0.181 * **		0.188 * **	0.176 * **	0.228 * **
Monitor	0.023 * **	-0.061 * **	0.071 * **	0.157 * **	0.012	-0.073 * **	0.075 * **	0.043 * **	-0.021 * **	0.116 * **	0.131 * **	0.258 * **		0.065 * **	-0.182 * **
ETR	-0.054 * **	-0.130 * **	0.019 * *	0.065 * **	0.075 * **	-0.215 * **	0.029 * **	-0.038 * **	-0.016 * *	0.129 * **	0.078 * **	0.103 * **	0.029 * **		0.108 * **
Age	-0.222 * **	-0.104 * **	0.014 *	0.154 * **	0.235 * **	0.066 * **	0.006	-0.162 * **	-0.111 * **	0.138 * **	-0.108 * **	0.185 * **	-0.152 * **	0.074 * **	
VIF		1.20	1.04	1.24	2.09	1.38	1.15	1.11	1.63	1.68	1.47	1.91	1.16	1.10	5.47

Note: The Pearson (Spearman) correlation coefficients are presented below (above) the main diagonal. * ** , * *, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. VIF, variance inflation factor.

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