Corporate liquidity policy, financing constraints, and financial intermediaries ☆

Katsutoshi Shimizu[a,*], Weihan Cui[b,]

[a] *Department of Economics, Nagoya University*
[b] *Graduate school of Economics, Nagoya University*

Abstract

This study investigates whether a constrained financial intermediary affects the *degree* of financing constraints of its borrower. We model a firm's demand for liquidity when its lender's monitoring alleviates its financing constraints. Since a healthier lender makes more monitoring investment to alleviate financing constraints, a firm does not need to hold much cash when its future profitability aggravates. In contrast, since an unhealthier lender makes less monitoring investment to aggravate financing constraints, a firm needs to hold more cash when its future profitability improves. Our empirical analysis provides supportive evidence for such model predictions. Our results indicate that constrained intermediaries affect the intertemporal allocation of investments and liquidity of its borrower in a bank-centered economy like Japan.

Keywords: Cash holding, Financial constraint, Monitoring, Japanese banks, Capital ratio

JEL classification: G31; G21; G35

1 Sept. 2016

☆The first author acknowledges funding support from Grant-in-Aid for Scientific Research.

*Corresponding author: Katsutoshi Shimizu, Department of Economics, Nagoya University.
Address: Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan. Tel.: +81-52-789-2378, Fax: +81-52-789-2378

Email addresses: `shimizu@soec.nagoya-u.ac.jp` (Katsutoshi Shimizu), `cui.weihan@b.mbox.nagoya-u.ac.jp` (Weihan Cui)

Contents

1 Introduction **1**

2 A model analysis **6**

2.1 Firm's optimal decision and borrowing constraint 6

2.2 Lender's optimal decision, moral hazard and monitoring investment 8

2.3 Implications of the model 12

3 Data and empirical methodology **14**

3.1 Data 14

3.2 Empirical methodology 14

4 Empirical Analysis **19**

4.1 Main results 19

4.2 Cash hoarding of non-financial firms and lender's liquidity 21

4.3 Robustness 21

4.4 Discussions 22

5 Conclusions **24**

1. Introduction

When a firm is confronted with market frictions, liquidity management becomes an issue of importance for corporate financial policy. As Almeida et al. (2004) argue, cash plays a role of efficiently allocating funds between different periods when financing is constrained. Constrained firms choose optimal cash policy to balance the profitability of current and future investments. A positive cash flow sensitivity of cash emerges, as a result of financing constraints. Although there is a large body of cash holdings literature, the relationship between financial constraints and liquidity management has not been much researched yet. At least, two questions should be addressed in this area of research. First, does the *degree* of financial constraints affect cash policy? In other words, does a relatively "more constrained" firm save more or less cash than a "less constrained" one? Second, is a lender able to alleviate financial constraints of its borrower? In other words, does lender's capacity of lending become a factor determining the degree of financial constraints of the borrower?

Our study addresses these two questions theoretically and empirically, with slightly greater emphasis on empirics. The first question is a familiar one and has been addressed intensively in the literature that examines the effects of financial constraints on corporate investment (Fazzari et al. 1988, Kaplan and Zingales 1997, Cleary 1999, Whited and Wu 2006, Lyandres 2007, Almeida and Campello 2007, Guariglia 2008, Hadlock and Pierce 2010, Gatchev et al. 2010, Andren and Jankensgard 2015, Farre–Mensa and Ljungqvist 2016, Chowdhury et al. 2016). However, this issue has been rarely researched in the literature of liquidity management and financing constraints except for a few studies.[1] Denis and Sibilkov (2009) argue that some constrained firms have low cash holdings because persistently low cash flows prevent them from accumulating cash. Luo (2011) argue that financial constraints play a disciplinary role in cash dissipation in the presence of agency problems.

The second question is related to familiar questions: are capital market supply frictions relevant for capital structure decisions (Faulkender and Petersen 2006, Leary 2009), do

[1] As we discuss later, Almeida et al. (2004) don't analyze this issue for a technical reason.

constrained financial intermediaries lead to inefficiency in investment or not (Paravisini 2008, Allen and Gale 2004), and how financing frictions in the financial intermediation sector affect lending behavior and economic activity, which has been of concern in the financial intermediation literature (Peek and Rosengren 1997, Kashyap and Stein 2000, Calomiris and Mason 2003, Khwaja and Mian 2008).[2] In the bank-centered economy like Japan, the empirical literature also provides evidence that financial intermediaries influence financial decisions of non-financial firms (Gibson 1995, Weinstein and Yafeh 1998, Kang and Stulz 2000, Hubbard et al. 2002, Iskandar-Datta and Jia 2012). In particular, Iskandar-Datta and Jia (2012) emphasize that the functioning of the financial system is crucial to corporate cash policy and find some divergence in cash practices across countries. They argue that the decelerating cash trend in Japan is ascribed to financial reforms. Francis et al. (2014) also examine the effects of banking deregulation on the cash policies of nonbanking firms in the United States. They find a significant and negative relation between intrastate banking deregulation and corporate cash holdings.

However, there is no study that addresses directly the second issue itself in the literature of corporate cash holdings, except for Hubbard et al. (2002). Their study is most related to the empirical part of our study and indicates that high-information-cost firms hold more cash when they are the loan customers of weak banks. In other words, such firms have much motives for precautionary savings. However, our efficient allocating model of liquidity, which is extended model of Almeida et al. (2004, 2011), depicts a different story. Our predictions critically depend on whether the future profitability rises or declines. If it rises, the firm tends to expand future investment. As the lender is healthier, the firm can increase both current and future borrowings more. Cash holdings allocate efficiently funds for investments. More cash is required as the lender is healthier and the firm can borrow more. In other words, cash holdings is positively related to lender's health, unlike Hubbard et al. (2002).

[2]As Leary (2009) argues, these studies tackled the usual assumption of Modigliani and Miller (1958) that the supply of funds is infinitely elastic, which results in the proposition that the cost of capital is determined solely by a firm's demand. Agca and Mozumdar (2008) argue that the investment-cash flow sensitivity decreases with factors that reduce capital market imperfections.

As the lender becomes unhealthier, the firm becomes "more" constrained and needs to contract both investments. If the future profitability declines, the firm tends to contract current investment more than future investment in order to rebalance the profitability. To do so, the firm needs to hold more cash as the lender is unhealthier. In other words, cash holdings are negatively related to lender's health.

In the theoretical part, we demonstrate how a lender's health alleviates the financing constraints and how a firm determines cash holdings. As a lender is healthier in terms of capital ratio, it invests more in its monitoring technology to increase a pledgeable income in the sense of Holmström and Tirole (1997). The greater pledgeable income alleviates the degree of financial constraint to which its borrowing firm is subject. Constrained financial intermediaries make worse the degree of financial constraints of the borrower by saving investment in monitoring technology. Since the direction of the effect of degree of financial constraint on cash holdings depends on the direction of profitability, the influence of constrained financial intermediaries also depends on the direction of a change in profitability. A firm becomes "more constrained" when its lender becomes more constrained. When the profitability of investment aggravates, more constrained financial intermediaries necessitates its borrower to save more.

After confirming empirically that cash flow sensitivity of cash is positive for financially constrained firms, our analysis provides empirical evidence that sensitivity of cash is positively related to its primary lender's capital ratio and liquidity ratio when a firm grows investment and vice versa. We employ three approaches suggested by the literature to identify financially constrained firms: payout policy, firm size, and access to bond markets. The variable that we empirically examine is not the level of cash, but differences in the sensitivity of cash holdings to cash, as the model predicts. The evidence suggests that, in a bank-centered economy, constrained financial intermediaries lead to inefficiency in investment and affect the intertemporal allocation of investments and allocation of liquidity. Corporate demands for liquidity depends on the constraints of financial intermediaries.

This study makes contributions to at least three strands of related literature. First, cash holding literature argue that cash holding is based on transaction motive (Mulligan

1997, Bigelli and Sanchez-Vidal 2012), precautionary motive (Opler et al. 1999, Almeida et al.2004, Acharya et al. 2007, Han and Qiu 2007, Palazzo 2012, Acharya et al. 2012, Chang et al. 2014), tax motive (Foley et al. 2007), agency motive (Dittmar et al. 2003, Dittmar and Mahrt–Smith 2007, Harford et al.2007, Gao et al. 2013), and liquidity insurance (Garcia-Appendini and Montoriol-Garriga 2013). Key determinants are leverage (Opler et al. 1999, Acharya et al. 2007), volatility of cash flow (Opler et al. 1999, Han and Qiu 2007), R&D investment (Bates et al. 2009), corporate governance (Ozkan and Ozkan 2004, Dittmar and Mahrt–Smith 2007, Kalcheva and Lins 2007, Fresard and Salva 2010, Kusnadi and Wei 2011, Chen et al. 2012, Jiang and Lie 2016), CEO compensation (Liu and Mauer 2011), diversification (Duchin 2010, Subramaniam et al. 2011), cost of carry (Azar et al. 2016), national culture (Chen et al. 2015), tax (Foley et al. 2007), and crisis(Campello et al. 2010).[3] We argue that lender's performance should be counted as a determinant of cash holdings. Since cash works as a substitute of external finance, it is important for borrowers whether their lenders afford to finance when they need.

Secondly, this study contributes to the banking literature emphasizing bank effects on decisions of non-financial firms. For example, Lemmon and Roberts (2010) argue that even large firms with access to public credit markets are susceptible to fluctuations in the supply of capital. Gibson (1995) argues that firm's investment is sensitive to the financial health of its main bank. Weinstein and Yafeh (1998) argue that slow growth rates of bank clients suggest that banks discourage firms from investing in risky profitable projects. Kang and Stulz (2000) argue that firms whose debt had a higher fraction of bank loans invested less than other firms did and that exogenous shocks to banks during the negotiations leading to the Basle Accord affected bank borrowers significantly. Houston and James (2001) document that bank-dependent firms hold larger stocks of liquid assets and have lower dividend payout rates. Our study adds the bank effect to the cash holdings

[3]Denis (2011) provides an excellent survey of the literature. Faulkender and Wang (2006) and Pinkowitz et al. (2006) argue that cash holdings are more valuable for constrained firm than unconstrained firms. Yun (2009), Lins et al.(2010), and Campello et al. (2011) argue that cash works as a complement to lines of credit. Bliss et al.(2015) argue that a shock to the supply of credit during the financial crisis increased the marginal benefit of cash retention.

of non-financial firms. [4]

Thirdly, our study contributes the theoretical literature of financing constraints (Whited 1992, Kiyotaki and Moore 1997, Kim et al. 1998, Almeida et al. 2004, Gamba and Triantis 2008,Whited and Wu 2006, Riddick and Whited 2009, Hirth and Viswanatha 2011, Hugonnier et al. 2015). The aforementioned question of whether constrained financial intermediaries lead to inefficiency or not has been under-researched. Our analysis is theoretically new in answering some aspects of such a question.[5] In particular, we add the analysis on the degree of financial constraint to the notion of cash flow sensitivity of cash as a measure of financial constraints argued in Almeida et al. (2004). Note that cash flow sensitivity of cash of constrained firms is not a direct function of the degree of the financial constraint in Almeida et al.(2004). In our model, the degree of the financial constraint depends on borrowing capacity and on cash flows. The difference comes from the difference in the assumption on curvatures of production functions. We argue that a change in the degree of financial constraints is generally relevant for liquidity policies and that it has a significant effect on the cash holdings.

Lastly, it is helpful to mention here the studies analyzing cash holdings of Japanese firms. Pinkowitz and Williamson (2001) argue that firms held greater cash when the Japanese banks had enormous power in the 1980s than they lost in 1990s. However, as documented by Nakajima and Sasaki (2016), Japanese firms recently resumed accumulation of cash to the highest cash-holding levels among developed economies. [6] This evidence casts doubt on the bank power hypothesis of Pinkowitz and Williamson (2001) because the bank relationship has been recently weakened rather than strengthened, at least for large listed firms in Japan. We will discuss how Japanese firms accumulated cash recently at the end of this study.

The organization of this paper is as follows: Section 2 describes the optimal cash

[4]Chava and Purnanandam (2011) argue that firms that primarily relied on banks for capital suffered larger valuation losses during the crisis and subsequently experienced a higher decline in their capital expenditure and profitability. Kahle and Stulz (2013) document that the bank-relationship firms have significantly higher cash holdings in the last year of the crisis than in the year before the crisis.

[5]In association with this question, Holmstrom and Tirole (1997) argue that a bank capital tightening hit poorly capitalized firms the hardest.

[6]See also table 1 of Kusnadi and Wei (2011).

holdings of non-financial firms and demonstrates how firms behave in the face of aggravation of lender's health. Section 3 describes data, empirical methodology, and hypotheses. Section 4 explains the estimated results of the main empirical analyses and provides the results of robustness check. Section 5 concludes our study.

2. A model analysis

In this section, we first describe firm's decision problem of investment and cash holding when the firm and its lender are financially constrained due to imperfect financial markets. A borrowing constraint forces the firm to hoard cash to implement optimal investments at present and in the future as in Almeida et al. (2004). Second, we elaborate the model by incorporating lender's optimal decision of lending and monitoring investment. A moral hazard issue constrains the amount of deposits that the lender affords to take and thereby the amount of lending. An increase in loans results in lender's higher monitoring investment, in turn, alleviates the borrowing constraint of the firm, and finally, weakens the corporate demands for liquidity.

2.1. Firm's optimal decision and borrowing constraint

There are three periods $t = 0, 1, 2$ and two states $s = H, L$. The state H occurs with probability p_H and L with p_L, respectively. At date $t = 0$, cash flow c_0 realizes, the firm invests I_0 that matures at $t = 2$. At date $t = 1$, the state realizes, the firm receives cash flow c_1^s and invests I_1^s that matures $t = 2$. Two investments may succeed or fail. The success probability is denoted by θ and the successes of two investments are perfectly correlated. The probability distribution of success is independent of the realization of the state. At date $t = 2$, if investments succeed, they produce $f(I_0) + g(I_1^s)$, and produce nothing otherwise. The production functions $f(\cdot)$ and $g(\cdot)$ have standard properties: $f' > 0$, $g' > 0$, $f'' < 0$, $g'' < 0$.

The firm borrows the amount B_0 at $t = 0$ and B_1^s at $t = 1$, respectively. We assume that the final returns f and g are not verifiable and cannot be contracted upon. The firm can pledge the collateralized value of underlying productive assets (Hart and Moore

1994, Holmström and Tirole 1997). Hence, the amounts of borrowing are constrained by collateralized values of investments. The importance of collateral in Japanese corporate borrowing is documented in Gan (2007) and Ogawa and Suzuki (2000). The borrowing capacity, namely the pledgeable amount that the lender is able to seize at date $t = 2$, is $(1-\tau)qI$ where $q \in (0,1)$ is the unit value of collateralized asset at $t = 2$ and $\tau \in (0,1)$ is the unit cost of liquidation. The lender is able to capture only the fraction $1-\tau$ of the collateralized assets. The cost of liquidation is considered to depend on the tangibility of a firm's assets, the legal strength of creditor's right, and the monitoring technology of the lender, the last of which we will focus on later. The value of the productive asset is zero when the investments fail.

We assume that the firm is risk-neutral and that a risk-free rate is zero. As Almeida et al. (2004) argues, the optimal cash holding is indeterminate when the firm is financially unconstrained. So we focus on the financially constrained firms to save the space. The decision problem is described as the followings:

$$\max_{C,I,z} E(\pi) = \theta \left(f(I_0) - \gamma B_0 + \sum\nolimits_{s=\{H,L\}} p_s \left(g(I_1^s) - \gamma B_1^s \right) \right) \tag{1}$$

$$\text{subject to } I_0 = c_0 + B_0 - C \tag{2}$$

$$I_1^s = c_1^s + z^s + B_1^s + C \qquad s = H, L \tag{3}$$

$$p_H z_H + p_L z_L = 1 \tag{4}$$

$$\gamma B_0 \le q(1-\tau) I_0 \tag{5}$$

$$\gamma B_1^s \le q(1-\tau) I_1^s \qquad s = H, L \tag{6}$$

Eq. (1) is the expected profit at $t = 2$. When the projects fail, the firm obtains nothing due to limited liability. The required rate of return of loans is denoted by γ. Eq. (2) and Eq. (3) are the budget constraint at $t = 0$ and $t = 1$, respectively. The firm hoards cash C at $t = 0$ to fund the investment at $t = 1$ by itself. As in Almeida et al. (2004), the firm is able to hedge the date 1 risky cash flow by trading z_s. By receiving in high cash flow state and paying in low cash flow state, the firm is able to hedge the risk of cash flow at $t = 1$. Eq. (4) represents the fair hedging condition. Eq. (5) and (6) represents financial constraints at $t = 0$ and $t = 1$, respectively.

When both of the financial constraints are binding at the optimum, the investment amounts become

$$I_0 = (c_0 - C)/\lambda \quad \text{and} \quad I_1^s = (c_1^s + C + z_s)/\lambda \tag{7}$$

from Eqs. (2) to (6). The denominator that appears in both equations is defined as $\lambda = 1 - (1 - \tau)q/\gamma$, which denotes the unit unpledgeable amount, plays the important role in the following analysis.

After substituting the above equations into Eq. (1), we obtain the first-order conditions

$$f'(I_0) = g'(I_1^H) = g'(I_1^L) \tag{8}$$

The firm optimally chooses the investments to equate the marginal productivities between date 0 and 1 and between two states. Since the production function is assumed not to vary across states, the optimal investment is the same in both states ($I_1^H = I_1^L \equiv I_1$). The full hedging enables to equate the marginal profitability between states and cash hoarding to equate those between dates.

Since the future investments in both states are the same, we have the budget constraint for total investment

$$I = I_0 + I_1 = (c_0 + E(c_1))/\lambda \tag{9}$$

from Eq. (7). Note that the full hedging implies that $c_1^s + z^s = E(c_1)$ at the optimum in both states. Therefore, the inverse of λ is interpreted as the multiplier of total investment to total cash flow. Lower λ enhances total investment more. As the unit value of collateralized asset q becomes higher, or, the unit cost of liquidation τ becomes lower, λ becomes lower. In this sense, λ represents the degree of financial constraint, which plays the key role in the following analysis.

2.2. Lender's optimal decision, moral hazard and monitoring investment

Now we introduce a lender's decision into the model. The lender lends the amount of $B = B_0 + B_1$ in total to the firm. At $t = 0$, the lender has equity capital K and collects deposits D from the perfectly competitive market. The lender lends to n homogeneous firms whose return is perfectly correlated. The date 0 balance sheet condition is $nB = D + K$. The lender obtains the repayment amount of loans $n\gamma B$ at $t = 2$ and repays rD to depositors only when the firms succeed to pay $n\gamma B$ to the lender. The depositors are risk neutral and the deposit rate is denoted by r. The final expected value of the lender is given by $E(V) = \theta\,(n\gamma B - rD) - \psi(x)$. To keep the analysis as simple as possible, we consider that the loan rate γ is exogenously determined outside the model. Usually, we can consider that there are competitors offering loan rates which are compared to that of our lender. We do not model such competition and assume that γ is exogenously given.

We make two primary assumptions. First, the unit cost of liquidation τ depends on lender's ability to monitor the firm projects. The higher ability the lender has, it is able to sell the collateral at a higher price. Furthermore, the lender is able to reduce the unit cost of liquidation τ by making investment $x \in (0, 1)$ in monitoring technology. We assume a linear relationship $1 - \tau = \phi x$ where $\phi \in (0, 1]$ is marginal benefit of the monitoring investment. It costs $\psi(x)$ for the lender to invest in monitoring technology, where ψ is an increasing convex function: $\psi' > 0, \psi'' > 0$. The lender makes this investment after it lends money to the firm and x is unverifiable in the contract.

Second, we introduce the financial constraint of the lender as in Acharya et al. (2010).[7] Since it is usual for depositors not to take collateral on lender's assets, we consider the moral hazard of Holmström and Tirole (1997), instead of the previous assumption that the lender is able to seize hard assets of the firm as in Hart and Moore (1994). If the lender exerts effort e, it is able to raise the success probability θ. Otherwise, it enjoys non-pecuniary private benefit b per lending. We denote the success probability when exerting effort by θ and by $\theta - \Delta\theta$ otherwise. Since the effort is assumed to be unverifiable, the incentive compatibility condition $\theta(n\gamma B - rD) \geq (\theta - \Delta\theta)(n\gamma B - rD) + bnB$ should be satisfied. In other words, lender's return is higher when exerting effort than otherwise. After rearranging this condition, we have $rD \leq (\gamma - b/\Delta\theta)nB$, where the right-hand side is the pledgeable income of depositors that is the maximal amount assuring depositors.

In addition, we make three assumptions: First, we assume that the pledgeable income

[7]Jayaratne and Morgan (2000) provides empirical evidence consistent with this.

per amount of loans is positive, $\gamma - b/\Delta\theta > 0$, to make the incentive constraint meaningful in the contract. Otherwise, no positive amount of deposit satisfying the constraint exists. Second, exogenously given required rate γ satisfies $\theta\gamma > 1$. In other words, the lender is able to earn more than the rate that assures risk neutral payoff. This assumption is required to assure lender's participation in the contract under the assumption of the additional cost of investment technology $\psi > 0$. Third, we assume $1 > \theta(\gamma - b/\Delta\theta)$. In other words, the pledgeable income is sufficiently small to assure the lender positive profit. This assumption is required because, if the expected pledgeable income $\theta(\gamma - b/\Delta\theta)$ is greater than unity, no profit remains in the hands of the lender.

The timeline is summarized as follows: At date 0, the lender chooses the number of borrowers and lend B_0 to each borrower. The firm chooses investment I_0 and cash hoardings C given cash flow c_0. The lender invests x in monitoring technology and exerts effort e. At date $t = 1$, the firm borrows B_1 and invests I_1 after the state and cash flow realize. At date $t = 2$, if the projects succeed, the lender repays to depositors after the firm obtains project returns and repays to the lender.

In this setup, the decision problem of the lender is described as follows:

$$\max_{n,x,D} E(V) = \theta\left(n\gamma B - rD\right) - \psi(x) \tag{10}$$

$$\text{subject to } nB = D + K \tag{11}$$

$$rD \leq (\gamma - b/\Delta\theta)nB \tag{12}$$

$$B \leq \gamma^{-1} q\phi x^*(I_0 + I_1) \tag{13}$$

$$\theta r = 1 \tag{14}$$

$$x^* = \arg\max_x (\theta\gamma - 1)n^*\gamma^{-1} q\phi x I + K - \psi(x) \tag{15}$$

$$E(V) \geq K \tag{16}$$

Since the lender does not care the amount of lending at each date, the problem is described in terms of total amount, i.e., $B = B_0 + B_1$. Eq. (10) is the final expected value of the lender. Eq. (11) is the balance sheet condition at date $t = 0$. Eq. (12) is the incentive compatibility constraint described above, which means that the amount of deposit repayments are constrained by the pledgeable income. Eq. (13) represents the collateral constraint of lending in total, which corresponds to the firm's constraints Eq. (5) and (6). Eq. (14) is the participation constraint of depositors. There is no informational asymmetry on the success probability between depositors and bank. Eq. (15)) is the incentive compatibility condition of the monitoring investment, which is obtained by substituting Eqs. (11) and (13) into Eq. (10). It describes that the lender optimally chooses monitoring investment x after it lends to n^* firms and knows total investment $I = I_0 + I_1$. By Eq. (16), we exclude uninteresting situation where the lender does not participate in the contract.

Solving this problem, we first observe that the assumption $\theta\gamma > 1$ assures the participation of the lender into the contract (Eq. (16)) and makes the maximization problem of Eq. (15) well defined together with the assumptions $\psi' > 0$ and $\psi'' > 0$. The first order condition for monitoring investment becomes

$$\psi'(x^*) = (\theta\gamma - 1)n^*\gamma q\phi I. \tag{17}$$

and the second order condition is satisfied.

In Eq. (12), from the assumption of positive pledgeable income, $\gamma - b/\Delta\theta > 0$, this constraint can be met by positive amount of deposits. Then, substituting Eq. (11) and (14), Eq. (12) reduces to

$$n \leq \frac{K}{(1 - \theta(\gamma - b/\Delta\theta))\, B^*} \equiv n^* \tag{18}$$

where B^* is given by Eq. (13) at equality. As long as the previous assumption $1 - \theta(\gamma - b/\Delta\theta) > 0$ holds, the constraint can be met for positive K and nB. From another assumption $\theta\gamma > 1$, the objective function $E(V) = (\theta\gamma - 1)nB^* + K - \psi(x^*)$ is linear and increasing in n. Therefore, the optimal number of borrowers n^* is the maximal number of integers that satisfies Eq. (18) at equality. We summarize these as a proposition:

Proposition 1: If the following assumptions: (i) $\gamma > b/\theta$, (ii) $\theta\gamma > 1$, and (iii) $1 > \theta(\gamma - b/\Delta\theta)$ hold, the lender provides each of n^* borrowers the amount of loans B^*, where

n^* is given by Eq. (18) and B^* is given by Eq. (13). The optimal monitoring investment x^* is given by Eq. (17).

2.3. Implications of the model

Now we analyze how lender's capital K affects firm's cash holdings. Substituting n^* and B^* into (17), we have

$$\frac{dx^*}{dK} = \frac{a}{\psi'' x + \psi'} > 0 \tag{19}$$

where $a = (\theta\gamma - 1)/((1 - \theta(\gamma - b/\Delta\theta))$. The positive sign comes from the fact that $\psi'' > 0$, $\psi' > 0$, and $a > 0$. As shown in Eq. (18), the greater capital enables the lender to provide loans with more borrowers. This is because the greater capital alleviates the financial constraint of the lender, hence enables the lender to increase the total loans. The greater amount of total loans increases lender's marginal benefit of monitoring investment, resulting in higher monitoring investment.

Next, going back to firm's decision problem, we derive the result on the relationship between lender's capital K and firm's cash holding. Totally differentiating Eq. (8), we have

$$\frac{dC^*}{dx} = \frac{dC^*}{d\lambda}\frac{d\lambda}{dx} = \frac{q\phi I_0 g''}{f'' + g''}\left(\frac{f''}{g''} - \frac{I_1}{I_0}\right) \tag{20}$$

[Appendix provides the calculations around this equation] The sign of this derivative depends on the growth rate of investment I_1/I_0 and the ratio of curvatures of production functions. To facilitate the following empirical analysis, we assume Cobb-Douglas production functions $f = I_0^{\alpha_0}$ and $g = I_1^{\alpha_1}$ hereafter. The sign of the above derivative becomes

$$\text{sgn}\left(\frac{dC^*}{dx}\right) = \text{sgn}(\alpha_1 - \alpha_0) \tag{21}$$

That is, dC^*/dx is negative when $\alpha_1 < \alpha_0$ and positive otherwise. In other words, the firm holds less cash to invest more at present when lender's monitoring investment is higher and the future profitability aggravates. The higher monitoring investment allows the lender to seize more collateral, which reduces the degree of firm's financial constraint and enables to hold less cash. Since the optimality requires more current investment when negative profitability shock occurs, the firm holds further less cash.

Combining Eq. (20) with Eq. (19), we have the following proposition.

Proposition 2 : The sensitivity of cash to lender's capital is negative when the firm decreases the future investment, and vice versa.

$$\mathrm{sgn}\left(\frac{dC^*}{dK}\right) = \mathrm{sgn}(I_1 - I_0) \tag{22}$$

Note that $dC^*/dK = (dC^*/dx^*)\ (dx^*/dK)$ and that the inequality $\alpha_1 < \alpha_0$ implies that $I_1 < I_0$ and vice versa.

Now we provide the graphical illustration behind this proposition. Figure 1 shows comparative statics when the firm becomes more constrained due to lender's capital change, assuming that negative technological shock occurs. The upper figure depicts the budget constraint given by Eq. (9) when the firm is less constrained (λ small) and when it is more constrained (λ large). Given current investment I_0, the firm needs to decrease future investment I_1 when the firm becomes more constrained. This decline in future investment improves profitability to distort the balance of profitability represented by Eq. (8), as shown in the lower figure. Since I_0 is larger than I_1 in this figure, the curvature of g is greater than f. Therefore, to recover the balance, the firm needs to decrease I_0 more than I_1. To decrease current investment more than future one, the firm saves more.[8]

Figure 2 represents the relationship between simulated optimal cash and exogenous lender's capital when the profitability improves (upward sloping curve) and when the profitability aggravates (downward sloping one). We set parameter values as $c_0 = 1$, $E(c_1) = 0.5$, $q = 0.9$, $\gamma = 1.1$, $\theta = 0.95$, $b = 0.1$, $\Delta\theta = 0.1$, and $\phi = 0.5$. The profitability parameters are $\alpha_0 = 0.5$, $\alpha_1 = 0.6$ for upward sloping curve and $\alpha_0 = 0.5$, $\alpha_1 = 0.4$ for downward sloping one. The simulated cash is calculated for lender's capital from $K = 0.1$ to $K = 0.9$.

[8]This can be shown as follows: From Eq. (7), the change in investments are $\Delta I_0 = (\Delta\lambda/\lambda)I_0 - \Delta C/\lambda$ and $\Delta I_1 = (\Delta\lambda/\lambda)I_1 + \Delta C/\lambda$. The inequality $\Delta I_0 < \Delta I_1$ reduces to $\Delta C > (I_0 - I_1)\lambda/2 > 0$, which assures that the change in cash becomes positive in this case.

Insert Figure 1 around here

Insert Figure 2 around here

3. Data and empirical methodology

3.1. Data

Our analysis employs Nikkei NEEDS-Financial QUEST database. The original data has the sample period 2000–2014. [9] The NEEDS-Financial QUEST database provides the borrowings amount database by firms. The original data contains 12,861 firm-year observations with 1,128 firms and 117 lenders at maximum. The sample includes firms that were listed on existing exchange and firms whose stocks are traded over-the-counter (JASDAQ). This original data does not include the observations of financial firms, but they are not restricted to manufacturing firms.[10] We eliminate firm-years for which book liability exceeded book assets. We also exclude the observations whose lender is not an ordinary bank, which are insurance companies, credit associations, foreign banks and governmental financial institutions.

3.2. Empirical methodology

Since our model predicts only for financially constrained firms, we select a sample of financially constrained firms from our original dataset. However, as is well-known, identifying those firms is a difficult task. Although several indices have been proposed in the

[9]The sample period starts from 2000 to avoid the period of bank M &A wave in the late 1990s.

[10]Our sample includes the following Nikkei Industry Classification: food, textile, paper, chemical, drugs, petroleum, rubber, ceramic glass, iron, non-ferrous metal, machinery, electrical equipment, shipbuildings, motor, transportation equipment, other manufacturing company, marine, mining, construction, trade, retail, real estate, railway, land transportation, sea transportation, air transportation, warehousing, communication, electric power, gas, and services.

literature, it seems that the literature has not reached a consensus on the proper definition of indices (Kaplan and Zingales 1997, Cleary 1999, Whited and Wu 2006, Hadlock and Pierce 2010, Farre–Mensa and Ljungqvist 2016). In particular, Almeida et al. (2004) examines Kaplan-Zingales index but find the estimated results very opposite to those of other measures. In addition, we don't know whether those coefficients used in indices hold for Japanese firms. For example, Cleary (2006) reports that Japanese firms exhibit exceptions in the interrelation between the measures of financial constraints. [11] For these reasons, we simply use the classical definitions to identify financially constrained firms as follows:

First, asset-constrained firms are those firms whose asset sizes are in the bottom three deciles of the original sample on an annual basis, following Gilchrist and Himmelberg (1995). The rationale behind this is the fact that small firms are typically vulnerable to imperfections of the financial market due to informational asymmetry. Second, payout-constrained firms are those firms whose payout ratios are in the bottom three deciles of the original sample on an annual basis. This criterion follows the classical work of Fazzari et al. (1988). As the third criterion, we employ access to the bond market. Weinstein and Yafeh (1998) emphasize that bond issuance has critically influences bank-firm ties. Access to bond market alleviates the financial constraint and weakens the role of bank lending.[12]

Japanese firms usually borrow from multiple banks. As is widely known, a primary lender has been called *main bank* which has been supposed to provide information- intensive lending service and oversee the restructuring of the distressed client (Sheard 1989, Aoki 1990, Hoshi et al. 1991, Weinstein and Yafeh 1998, Morck and Nakamura 1999). As Gibson (1995) argues, identifying a firm's main bank is not trivial. There were once at least four identifiers: 1) the presence of a bank employee on the firm's board of directors, 2) the largest shareholding in the firm, 3) as the primary reference for the firm identified

[11]Kadapakkam et al. (1998) also argue that in all countries except for Japan, the cash flow variable contributes to the explanatory power of the investment regression.

[12]We examine bond access instead of bond ratings. Although Almeida et al. (2004) examine commercial paper ratings, we do not because there are relatively small number of firms issuing commercial papers.

in the Japan Company Handbook, and 4) the largest lender in the firm. Although the role of the main bank has been changing since the 1980s as argued in Weinstein and Yafeh (1998) and Wu and Yao (2012), it is still considered to have a certain role, at least in corporate restructuring. As documented in Inoue et al. (2008), banks led 74% of relief attempts as the main bank in Japan. Therefore, we have a reason to focus on the capital ratio of the main bank rather than other lenders because it is how the main bank manages a distressed borrower's restructuring that influences the key notion in our theoretical prediction, namely collateral value or pledgeable income.

Note that Inoue et al. (2008) argue that private restructurings led by main banks failed because of delays in implementing fundamental solutions. This result may seem inconsistent with our model prediction. However, failed restructuring by the main bank does not mean that such restructuring plan is inferior to other plans from the viewpoint of lenders. In other words, whether the main bank succeeded to manage the distressed borrower still remains an empirical question. [13]

We simplify our empirical analysis by defining the main bank as the lender that provides the largest amount of loans and assuming that only a main bank's decision affects its borrower's decision. Hereafter, we call it a primary lender not to invoke confusions because the role of the main bank has changed since the time when such word was used in the 1990s and because some articles use this word to mean the notion different from the past usage.

We consider the following baseline cash holding equation:

$$\Delta C_{it} = \beta_0 + \beta_1 y_{it} + \beta_2^{D_{it}} k_{it} + \beta_3 Q_{it} + \epsilon_{it} \tag{23}$$

The dependent variable is a change in cash ratio $\Delta C_{it} = C_{it} - C_{i,t-1}$ of the i-th firm at year t. Cash ratio is the sum of cash and deposit (cash equivalents) divided by book asset. Cash flow ratio y_{it} is defined as the sum of ordinary income and depreciation divided by book asset. Capital ratio of the primary lender is denoted by k_{it}. When a firm borrows

[13] On other favorable aspects of the main bank, Kutsuna et al. (2007) find that main bank relationships give small issuers increased access to equity capital markets.

the same amount from multiple banks, k_{it} is defined as the average of capital ratios of the banks whose loan amounts are in a tie. We use regulatory capital ratio because the capital regulation can be regarded more binding constraint than the constraint of deposit supply.

We also examine liquidity ratio of the primary lender as an alternative of k_{it}. This additional exercise is motivated by the finding that a bank's liquidity shock impacts its loans to the borrower (Khwaja and Mian 2008). As we will discuss later, although the previous model ignores liquidity holdings by a lender, the lender is able to increase its loans when it has excess liquidity.

In Eq. (23), the dummy variable D_{it} takes 1 if the firm investment grows and 0 otherwise. We define $D_{it} = 1$ if the investment grows $I_{i,t+1} > I_{it}$ and $D_{it} = 0$ otherwise.[14] We include Tobin's Q which is the ratio of market value of the asset to book asset, denoted by Q_{it}, as a control variable. Cash policy is influenced by the growth opportunity of the firm represented by Q. Although the future growth opportunity that is available to the firm is difficult to measure, in principle, we predict that the coefficient of Q is positive. [15] In addition, we include change in short-term debt, asset size, and leverage as control variables in other specifications, following the existing literature.[16] Changes in the ratio of short-term debt to total assets is predicted to positively influence cash if firms use short-term debt to build cash reserves. However, it is predicted to negatively influence cash because cash can be regarded as a negative debt, substitutable for debt. The coefficient of leverage is predicted negative because firms use cash to pay down leverage. Firm size is predicted to be negatively related to cash holdings because there exists a scale economy in holding cash for transactions.

From Proposition 2, we make the main hypothesis as

[14] This specification precisely follows the two-period setup of the previous model. The deficiency of this specification is that actual firms are considered to decide the cash hoardings in a multi-period greater than two. To moderate this deficiency of the two-period setup, we tried employing the three-periods moving average of investment. The results do not change if we use this alternative specification.

[15] Almeida et al. (2004) argue that measurement error issue does not arise when we have financial variable, instead of real variable, as a dependent variable.

[16] In addition, we examined change in net working capital, capital expenditures, and volatility of cash flow as control variables. We do not provide the results including them in the following section.

H_1: A financially constrained firm saves less when its primary lender has a higher capital ratio as long as its investment growth is negative ($\beta_2^0 < 0$). Otherwise, it saves more when its primary lender has a higher capital ratio ($\beta_2^1 > 0$).

Also, we test the second hypothesis:

H_2: A financially constrained firm saves more when it has more cash flow ($\beta_1 > 0$). By testing this hypothesis, we are able to confirm that our model prediction is also empirically valid in a bank-centered economy, compared to a finding in Almeida et al.(2004). Riddick and Whited (2009) find contrasting evidence that the cash flow sensitivity of cash is negative. Bao et al. (2012) argue that the cash flow sensitivity of cash is asymmetric to cash flow. Cash flow sensitivity of cash is negative when a firm faces a positive cash flow environment, but it is positive when a firm faces negative cash flows.

Table 1 around here

Table 1 presents the summary statistics for asset-constrained firms, payout-constrained firms and firms without access to bond market separately. Constrained firms hold on average 10-14% of their assets in the form of cash equivalents. Mean of cash holdings is highest for asset-constrained firms and lowest for payout-constrained firms. [17] Mean of cash flow varies from 5% to 7%, and payout-constrained firms have the lowest mean among three. Japanese firms hold cash twice as much as cash flow on average. Tobin's Q are almost one for each constrained firm. [18] Approximately 60% of constrained firms grow investment while the others decline investment. Lender's capital ratio is approximately 12% and its liquidity ratio is 5%. Appendix D provides the number of constrained firms for each criterion.

[17] These means are not much different from, but a bit lower than those reported in Almeida et al.(2004).

[18] Change in short-term debt is -0.9% for asset-constrained firms and payout-constrained firms, and is -0.8% for firms without access to the bond market. These negative mean may indicate that cash holdings are used to pay down debt, besides of investment. Asset-constrained firms have the lowest leverage of 2.211 while payout-constrained firms have the highest, and the highest standard deviation of leverage shows in panel of firms without access to bond market, which is more than twice as the other two criteria.

4. Empirical Analysis

4.1. Main results

In Table 2, we have 3,451 asset-constrained firms in Panel A, 3,144 payout-constrained firms in Panel B and 6,088 firms without access to bond market in Panel C. In each panel, we estimate the regression equation (23) by splitting the sample into two subsamples: firms having positive growth of investment and those of negative growth. We follow a usual sample splitting method to alleviate the issue of potential endogeneity that choosing positive or negative growth may bias the coefficient estimates due to the correlation of error terms. [19] In each panel, the first two columns present the result of baseline regression, and the latter two columns present the estimation results with a change in short-term debt, leverage and size being control variables. We estimate these models by instrumental variable GMM (generalized method of moments) to alleviate the issue of endogenities of main variables. As instrumental variables, we employ a ratio of the number of employees to total asset, ratio of sales to total asset, a dummy representing whether the firm is listed on stock exchange or not, net working capital, year dummies, and industry dummies, in addition to lags of variables included in equations. Reported estimates are two-step one and standard errors are Windmeijer bias-corrected one robust to heteroscedastic errors.

The coefficient of lender's capital ratio is significantly positive in the model (1) of Panel A, and it is significantly negative in the model (2). These signs are consistent with the hypothesis H_1. When an asset-constrained firm invests more due to favorable technological shock, it saves more as its primary lender is healthier. In contrast, when it invests less due to adverse technological shock, it saves less as its primary lender is healthier. The estimates are not much different if we include control variables in the models (3) and (4), respectively.

The cash flow sensitivity of cash in panel A are positive and significant in all estimations, consistent with hypothesis H_2 and the existing literature. A constrained firm

[19]The results are not much different if we use dummy variables method or threshold effects model without splitting the sample. See Barnett and Sakellaris (1998) and Hansen (1999).

tends to save more cash when its cash flow increases. However, we find that the sensitivity is remarkably higher for negative growth than that of positive growth. This is because the firm that decreases future investment is able to accumulate cash more than the counterpart.

The coefficients of Tobin's Q are positive for positive growth firms and negative for negative growth firms. The existing literature argues that financially constrained firms tend to increase their cash holdings when they have more growth opportunities (Opler et al. 1999, Bates et al. 2009, and Almeida et al. 2004). [20] Almeida et al. (2004) report that replacing Q with investment growth produces no different results in their analysis. In our analysis, if we regard Q as investment growth, the result means that a firm decreasing investment has higher cash. This is consistent with the view, which is prevalent in Japan, that there are not many profitable opportunities to invest, so such a firm accumulates cash. However, such a story casts doubt on that those firms declining investment are really financially constrained.

As shown in panel B and C, the main results for payout-constrained firms and firms without access to bond markets are similar to asset-constrained firms, respectively. The coefficients of Tobin's Q shows similar tendencies in column (1) and (2) of panel B while they lose significance in other columns. Among control variables, the coefficients of short-term debt are positive in (4) of Panel B and C, consistently with Almeida et al. (2004) in that firms with more short-term debt tend to save more cash when facing financial constraints. Leverage and size mostly show negative but insignificant results. The signs are consistent with Bates et al. (2009), indicating that constrained firms use cash to pay down leverage, and Opler et al. (1999), indicating that constrained firms with large book assets tend to save less cash.

Table 2 around here

[20] Nakajima and Sasaki (2016) argue that Japanese firms tend to hold less cash when they have growth opportunities. Our finding is consistent with most of existing literature for positive growth firms are while it is consistent with Nakajima and Sasaki (2016) for negative growth firms.

4.2. Cash hoarding of non-financial firms and lender's liquidity

Next, we consider the modified hypothesis of hypothesis 1, using liquidity ratio of primary lender instead of its capital ratio. As mentioned already, Khwaja and Mian (2008) find evidence that a bank's liquidity shock impacts its loans to the borrower. Although the previous model ignores liquidity holdings by the lender, the lender is possibly able to increase the loans when it has excess liquidity. The modified hypothesis is

H_1': A financially constrained firm saves less when its primary lender has a higher liquidity ratio as long as its investment growth is negative. Otherwise, it saves more when its primary lender has a higher liquidity ratio.

This analysis also complements the previous analysis, in particular stressing that lenders' financial constraint plays the key role in determining firms' cash hoardings. A cash-rich lender affords to provide more loans using excess cash and benefits from monitoring investment, resulting in firm's higher investment.

Table 3 around here

Table 3 reports the estimation results to examine a lender's liquidity effect for each constrained type. Cash flow shows positive and significant estimates again in all panels, consistently with the hypothesis 2. Also, we find significantly positive and negative effect of lender's liquidity for positive growth firms and negative growth firms, respectively. A financially constrained firm with declining investment saves less when its primary lender has a higher liquidity ratio while a financially constrained firm with growing investment saves more when its primary lender has a higher liquidity ratio. The modified hypothesis H_1' holds empirically.

4.3. Robustness

Finally, we examine the alternative definition of financing constraints as a robustness check. Previously, we defined financial constraints on an annual basis. Now we define financial constraints by ranking firms based on time-series averages of each firm. Then, our sample becomes firms that are financially constrained, on average, throughout the period. Since firm size usually does not change greatly year by year, we expect that two definitions do not produce the different results. Since financially constrained firms may increase or decrease payouts year by year, we may have different results. In particular, according to the previous definition of constraints, the firm that is considered financially constrained in the previous year may become non-constrained after a year, and vice versa. In other words, some firms are in and out of the sample in panel model, results in missing values. Although such missing values may not cause any difficulty, the alternative definition has an advantage in not causing such missing values. As Table 4 reports, the estimated results are not much different even for payout-constrained firms, again consistent with our hypothesis 1 and 2. This result suggests that our previous analysis is robust to the definition of financial constraints.

Table 4 around here

4.4. Discussions

We discuss here our results in terms of several aspects. As argued in Bao et al. (2012), there is two contrasting evidence on the cash flow sensitivity of cash. Unlike Almeida et al. (2004), Riddick and Whited (2009) find a negative propensity to save, as their dynamic investment model predicts. Bao et al. (2012) argue that the cash flow sensitivity of cash is asymmetric to cash flow. Its sign is dependent on the sign of cash flow. In this sense, Bao et al. (2012) provide evidence supporting both of Almeida et al. (2004) and Riddick and Whited (2009). In contrast, our results advocate the positive sensitivity. We find the asymmetric effect of bank health on cash rather than that of cash flow. Furthermore, our signs do not depend on signs of cash flow, but signs of investment growth. In our view, there still remains a room to investigate the issue of the sign of cash flow sensitivity of cash for several reasons.

First, one of the limitations of our model is that it consists just of two periods. Unlike the assumptions in Riddick and Whited (2009), we assumed that the profitability changes from the present to the future. More generally, as in Riddick and Whited (2009), the technological shock at present may have persistent effects on the future investments, hence cash holdings.

However, as Lyandres (2007) emphasizes, the more general approach may allow the timing of investments. The second limitation of our model is the exogenous timing of investments. If we allow such an endogenous timing, the investment curve may become U-shaped as in the recent studies, which may result in the non-monotonic relation between cash and cash flow.

The third point is the relation between Tobin's Q and financial constraints, as mentioned earlier. Ideally, Tobin's Q contains all the information of future marginal profitability. Our assumption here is that the bank ameliorates financial constraints at present and in the future, uniformly. This assumption can be relaxed by considering a more rich model where the bank health varies across time. In this case, Tobin's Q is also dependent on the future performances of the banks and firms adjust cash holdings expecting future bank health.

According to Kusnadi and Wei (2011) investigating 39 countries over the period 1995 to 2004, Japanese firms hold the second highest cash ratios. Our analysis provides the reason for this phenomenon. A firm has high cash holding ratio either because its primary lender has strong balance sheet and the firm grows investment or because the lender has the weak balance sheet and the firm declines investment. One side of this polarization advocates the evidence in Pinkowitz and Williamson (2001) for the different reason. The other side is consistent with agency view of cash holdings in the literature. The latter casts doubt on the lending relationship in the sense that the firm finds it better to switch the relationship with other healthier banks if it has a good opportunity of investments. Such firm maintains its relationship because it does not have a good growth opportunity.

5. Conclusions

This study investigates whether lender's health influences cash hoardings of financially constrained firms. Theoretical prediction is that sign of the sensitivity of cash to lender's health depends crucially on a change in profitability. When profitability improves, a financially constrained firm grows investment and its lender's health has a positive influence on cash holdings. Otherwise, it contracts investment and its lender's health has a negative influence on cash holdings. In other words, a firm holds greater cash when (i) it grows investment and its lender is healthy or (ii) it contracts investment and its lender is not healthy than otherwise. This theoretical result implies that cash holdings move moderately when its lender keeps its health at a moderate level.

Our empirical analysis provides supportive evidence for our theoretical prediction. Even in a bank-centered economy like Japan, cash flow sensitivity of cash is positive for financially constrained firms, supporting evidence of Almeida et al. (2004). And there exist lender's effects in corporate cash holdings. This empirical evidence does not depend on the bank power theory discussed in Pinkowitz and Williamson (2001). Even during the era which the bank lost their power, financial decisions of non-financial firms depends on the performance of its lender in a bank-centered economy. This is because the monitoring investment by such lender affects the collateral value of the productive assets of the non-financial firm.

Note that, in our analysis, higher capital of financial intermediary is able to make its borrower "less financially constrained" at the cost of monitoring investment. In this sense, constrained financial intermediaries have impacts on the inefficiency of investment and liquidity management of the firm. However, unlike the analysis in Hubbard et al. (2002), the effect is not one way. Higher cash holdings itself does not necessarily mean that the firm is "more constrained". It means so only in the case of weak capital or shortage of liquidity on the side of the lender.

Lastly, although Nakajima and Sasaki (2016) argue that bank-dependent firms accumulate cash for reasons other than precautionary demands, our evidence does not support their argument. Rather, we argue that precautionary demands theory, two combinations above (growing firm with the healthier lender and declining firm with the unhealthier lender), is able to explain that accumulation.

References

Acharya, V., Almeida, H., Campello, M. 2007. Is cash negative debt? A hedging perspective on corporate financial policies. Journal of Financial Intermediation 16, 515–554.

Acharya, V., Davydenko, S., Strebulaev, I. 2012. Cash holdings and credit risk. Review of Financial Studies 25, 3572–3609.

Acharya, V., Shin, H., Yorulmazer, T. 2010a. Crisis resolution and bank liquidity. Review of Financial Studies 24, 2166–2205.

Agca S., Mozumdar, A. 2008. The impact of capital market imperfections on investment-cash flow sensitivity. Journal of Banking & Finance 32, 207–216.

Allen, F., Gale, D. 2004. Financial intermediaries and markets. Econometrica 72, 1023–1061.

Almeida, H., Campello, M. 2007. Financial constraints, asset tangibility, and corporate investment. Review of Financial Studies 20, 1429–1460.

Almeida, H., Campello, M., Weisbach, M. 2004. The cash flow sensitivity of cash. Journal of Finance 59, 1777–1804.

Almeida, H., Campello, M., Weisbach, M. 2011. Corporate financial and investment policies when future financing is not frictionless. Journal of Corporate Finance 17, 675–693.

Andren, N., Jankensgard, H. 2015. Wall of cash: The investment-cash flow sensitivity when capital becomes abundant. Journal of Banking & Finance 50, 204–213.

Aoki, M., 1990. Toward an economic model of the Japanese firm. Journal of Economic Literature 28, 1–27.

Azar, J., Kagy, J., Schmalz, M. 2016. Can changes in the cost of carry explain the dynamics of corporate "cash" holdings? Review of Financial Studies 29, 2194–2240.

Bao, D., Chan K., Zhang, W. 2012. Asymmetric cash flow sensitivity of cash holdings. Journal of Corporate Finance 18, 690–700.

Barnett, S., Sakellaris, P. 1998. Nonlinear response of firm investment to Q: Testing a model of convex and non-convex adjustment costs. Journal of Monetary Economics 42, 261–288.

Bates, T., Kahle, K., Stulz, R. 2009. Why do U.S. firms hold so much more cash than they used to? Journal of Finance 64, 1985–2021.

Bigelli, M., Sanchez-Vidal, J. 2012. Cash holdings in private firms. Journal of Banking & Finance 36, 26–35.

Bliss, B. Cheng, Y., Denis, D. 2015. Corporate payout, cash retention, and the supply of credit: Evidence from the 2008–2009 credit crisis. Journal of Financial Economics 115, 521–540.

Calomiris, C., Mason, J. 2003. Consequences of bank distress during the Great Depression. American Economic Review 93, 937–947.

Campello, M., Giambona, E., Graham, J., Harvey, C. 2011. Liquidity management and corporate investment during a financial crisis. Review of Financial Studies 24, 1944–1979.

Campello, M., Graham, J., Harvey, C. 2010. The real effects of financial constraints: Evidence from a financial crisis. Journal of Financial Economics 97, 470–487.

Chang, X., Dasgupta, S., Wong, G., Yao, J. 2014. Cash-flow sensitivities and the allocation of internal cash flow. Review of Financial Studies 27, 3628–3657.

Chava, S., Purnanandam, A. 2011. The effect of banking crisis on bank - dependent borrowers. Journal of Financial Economics 99, 116–135.

Chen, Q., Chen, X., Schipper, K., Xu, Y., Xue, J. 2012. The sensitivity of corporate cash holdings to corporate governance. Review of Financial Studies 25, 3610–3644.

Chen, Y., Dou, P., Rhee, G., Truong, C., Veeraraghavan, M. 2015. National culture and corporate cash holdings around the world. Journal of Banking & Finance 50, 1–18.

Chowdhury, J., Kumar, R., Shome, D. 2016. Investment-cash flow sensitivity under changing information asymmetry. Journal of Banking & Finance 62, 28–40.

Cleary, S. 1999. The relationship between firm investment and financial status. Journal of Finance 54, 673–692.

Cleary, S. 2006. International corporate investment and the relationships between financial constraint measures. Journal of Banking & Finance 30, 1559–1580.

Denis, D. 2011. Financial flexibility and corporate liquidity. Journal of Corporate Finance 17, 667–674.

Denis, D., Sibilkov, V. 2009. Financial constraints, investment, and the value of cash holdings. Review of Financial Studies 23, 247–269.

Dittmar, A., Mahrt-Smith, J., Servaes, H. 2003. International corporate governance and corporate cash holdings. Journal of Financial and Quantitative Analysis 38, 111–133.

Dittmar, A., Mahrt-Smith, J. 2007. Corporate governance and the value of cash holdings. Journal of Financial Economics 83, 599–634.

Duchin, R. 2010. Cash holdings and corporate diversification. Journal of Finance 65, 955–992.

Faulkender, M., Petersen, M. 2006. Does the source of capital affect capital structure? Review of Financial Studies 19, 45–79.

Farre–Mensa, J., Ljungqvist, A. 2016. Do measures of financial constraints measure financial constraints? Review of Financial Studies 29, 271–308.

Faulkender, M., Wang, R. 2006. Corporate financial policy and the value of cash. Journal of Finance LXI, 1957–1990.

Fazzari, S., Hubbard, R., Petersen, B. 1988. Financing constraints and corporate investment. Brookings Papers on Economic Activity 1, 141–206.

Foley, C., Hartzell, J., Titman, S., Twite, G. 2007. Why do firms hold so much cash? A tax-based explanation. Journal of Financial Economics 86, 579–607.

Francis, B., Hasan, I., Wang, H. 2014. Banking deregulation, consolidation, and corporate cash holdings: U.S. evidence. Journal of Banking & Finance 41, 45–56.

Fresard, L., Salva, C. 2010. The value of excess cash and corporate governance: Evidence from US cross-listings. Journal of Financial Economics 98, 359–384.

Gamba, A., Triantis, A. 2008. The value of financial flexibility. Journal of Finance LXIII, 2263–2296.

Gan, J. 2007. Collateral, debt capacity, and corporate investment: Evidence from a natural experiment. Journal of Financial Economics 85, 709–734.

Gao, H., Harford, J., Li, K. 2013. Determinants of corporate cash policy: Insights from private firms. Journal of Financial Economics 109, 623–639.

Garcia-Appendini, E. Montoriol-Garriga, J. 2013. Firms as liquidity providers: Evidence from the 2007-2008 financial crisis. Journal of Financial Economics 109, 272–291.

Gatchev, V., Pulvino, T., Tarhan, V. 2010. The interdependent and intertemporal nature of financial decisions: An application to cash flow sensitivities. Journal of Finance LXV, 725–763.

Gilchrist, S., Himmelberg, C. 1995. Evidence on the role of cash flow for investment. Journal of Monetary Economics 36, 541–572.

Gibson, M. 1995. Can bank health affect investment? Evidence from Japan. Journal of Business 68, 281–308.

Guariglia, A. 2008. Internal financial constraints, external financial constraints, and investment choice: Evidence from a panel of UK firms. Journal of Banking & Finance 32, 1795–1809.

Hadlock, C., Pierce, J. 2010. New evidence on measuring financial constraints: Moving beyond the KZ index. Review of Financial Studies 23, 1909–1940.

Han, S., Qiu, J. 2007. Corporate precautionary cash holdings. Journal of Corporate Finance 13, 43–57.

Hansen, B. 1999. Threshold effects in non-dynamic panels: Estimation, testing, and inference. Journal of Econometrics 93, 345–368.

Harford, J., Mansi, S.,Maxwell, W. 2007. Corporate governance and firm cash holdings in the U.S. Journal of Financial Economics 87, 535–555.

Harford, J., Klasa, S., Maxwell, W. 2014. Refinancing risk and cash holdings. Journal of Finance LXIX, 975-1012.

Hart, O., Moore, J. 1994. A theory of debt based on the inalienability of human capital. Quarterly Journal of Economics 109, 841–879.

Hirth, S., Viswanatha, M. 2011. Financing constraints, cash-flow risk, and corporate investment. Journal of Corporate Finance 17, 1496–1509.

Holmström, B.,Tirole, J. 1997. Financial intermediation, loanable funds, and the real sector. Quarterly Journal of Economics 112, 663–691.

Hoshi, T., Kashyap, A., Scharfstein, D. 1991. Corporate structure, liquidity, and investment: Evidence from Japanese industrial groups. Quarterly Journal of Economics 106, 33–60.

Hubbard, R., Kuttner, K., Palia, D. 2002. Are there bank effects in borrowers' costs of funds? Evidence from a matched sample of borrowers and banks. Journal of Business 75,559–581.

Hugonnier, J., Malamud, S., Morellec, E. 2015. Capital supply uncertainty, cash holdings, and investment. Review of Financial Studies 28, 391–445.

Inoue, K., Kato, H., Bremer, M. 2008. Corporate restructuring in Japan: who monitors the monitor? Journal of Banking & Finance 32, 2628–2635.

Iskandar-Datta, M., Jia, Y. 2012. Cross-country analysis of secular cash trends. Journal of Banking & Finance 36, 898–912.

Jayaratne, J., Morgan, D. 2000. Capital market frictions and deposit constraints at banks. Journal of Money, Credit and Banking 32, 74–92.

Jiang, Z., Lie, E. 2016. Cash holding adjustments and managerial entrenchment. Journal of Corporate Finance 36, 190–205.

John, T. 1993. Accounting measures of corporate liquidity, leverage, and costs of financial distress. Financial Management 22, 91–100.

Kadapakkam, P., Kumar, P., Riddick, L. 1998. The impact of cash flows and firm size on investment: The international evidence. Journal of Banking & Finance 22, 293–320.

Kahle, K., Stulz, R. 2013. Access to capital, investment, and the financial crisis. Journal of Financial Economics 110, 280–299.

Kalcheva, I., Lins, K. 2007. International evidence on cash holdings and expected managerial agency problems. Review of Financial Studies 20, 1087–1112.

Kang, J-K., Stulz, R., 2000. Do banking shocks affect borrowing firm performance? An analysis of the Japanese experience. Journal of Business 73, 1–23.

Kaplan, S., Zingales, L. 1997. Do investment-cash flow sensitivities provide useful measure of financing constraints? Quarterly Journal of Economics 112, 169–215.

Kashyap, A., Stein, J. 2000. What do a million observations on banks say about the transmission of monetary policy? American Economic Review 90, 407–428.

Khwaja, A., Mian, A. 2008. Tracing the impact of bank liquidity shocks: Evidence from an emerging market. American Economic Review 98, 1413-1442.

Kim, C., Mauer, D., Sherman, A. 1998, The determinants of corporate liquidity: Theory and evidence. Journal of Financial and Quantitative Analysis 33, 335– 359.

Kiyotaki, N., Moore, J. 1997. Credit cycles. Journal of Political Economy 105, 211–248.

Kusnadi, Y., Wei, K. 2011. The determinants of corporate cash management policies: Evidence from around the world. Journal of Corporate Finance 17, 725–740.

Kutsuna, K., Smith, J., Smith, R., 2007. Banking relationships and access to equity capital markets: Evidence from Japan's main bank system. Journal of Banking & Finance 31, 335–360.

Leary, M. 2009. Bank loan supply, lender choice, and corporate capital structure. Journal of Finance 64, 1143–1185.

Lemmon, M., Roberts, M. 2010. The response of corporate financing and investment to changes in the supply of credit. Journal of Financial and Quantitative Analysis 45, 555–587.

Lins, K., Servaes, H., Tufano, P. 2010. What drives corporate liquidity ? An international survey of cash holdings and lines of credit. Journal of Financial Economics 98, 160–176.

Liu, Y., Mauer, D. 2011. Corporate cash holdings and CEO compensation incentives. Journal of Financial Economics 102, 183–198.

Luo, M. 2011. A bright side of financial constraints in cash management. Journal of Corporate Finance 17, 1430–1444.

Lyandres, E. 2007. Costly external financing, investment timing, and investment-cash flow sensitivity. Journal of Corporate Finance 13, 959–980.

Modigliani, F., Miller, M. 1958. The cost of capital, corporation finance and the theory of investment. American Economic Review 48, 261–297.

Morck, R., Nakamura, M. 1999. Banks and corporate control in Japan. Journal of

Finance 54, 319–339.

Mulligan, C. 1997. Scale economies, the value of time, and the demand for money: Longitudinal evidence from firms. Journal of Political Economy 105, 1061–1079.

Nakajima, K., Sasaki, T. 2016. Bank dependence and corporate propensity to save. Pacific–Basin Finance Journal 36, 150–165.

Ogawa, K., Suzuki, K. 2000. Demand for bank loans and investment under borrowing constraints: A panel study of Japanese firm data. Journal of the Japanese and International Economies 14, 1–21.

Opler, T., Pinkowitz, L., Stulz, R., Williamson, R. 1999. The determinants and implications of corporate cash holdings. Journal of Financial Economics 52, 3–46.

Ozkan, A., Ozkan, N. 2004. Corporate cash holdings: An empirical investigation of UK companies. Journal of Banking & Finance 28, 2103–2134.

Palazzo, B. 2012. Cash holdings, risk, and expected returns. Journal of Financial Economics 104, 162–185.

Paravisini, D. 2008. Local bank financial constraints and firm access to external finance. Journal of Finance 63, 2161–2193.

Peek, J., Rosengren, E. 1997. The international transmission of financial shocks: The case of Japan. American Economic Review 87, 495–505.

Pinkowitz, L., Williamson, R. 2001. Bank power and cash holdings: Evidence from Japan. Review of Financial Studies 14, 1059–1082.

Pinkowitz, L., Stulz, R., Williamson, R. 2006. Does the contribution of corporate cash holdings and dividends to firm value depend on governance? A cross-country analysis. Journal of Finance LXI, 2725–2751.

Riddick, L., Whited, T. 2009. The corporate propensity to save. Journal of Finance LXIV, 1729–1766.

Sheard, P. 1989. The main bank system and corporate monitoring and control in Japan. Journal of Economic Behavior and Organization 11, 399–422.

Subramaniam, V., Tang, T., Yue, H., Zhou, X. 2011. Firm structure and corporate cash holdings. Journal of Corporate Finance 17, 759–773.

Weinstein, D., Yafeh, Y. 1998. On the costs of a bank centered financial system: Evidence from the changing main bank relations in Japan. Journal of Finance 53, 635–672.

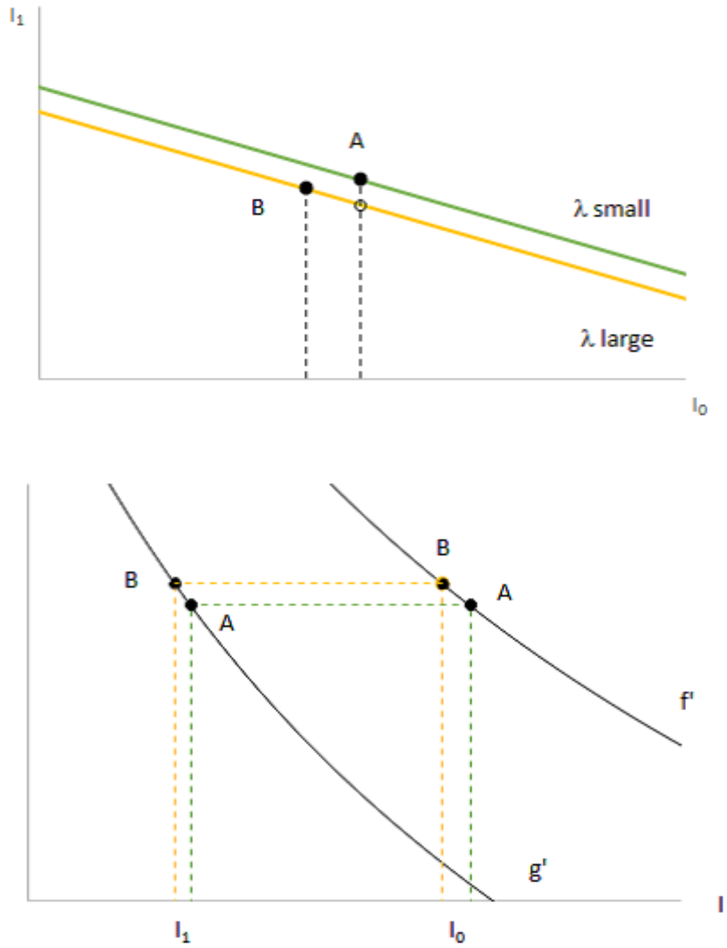
Whited, T. 1992. Debt, liquidity constraints, and corporate investment: Evidence from panel data. Journal of Finance 47, 1425–1460.

Whited, T., Wu, G. 2006. Financial constraints risk. Review of Financial Studies 19, 531–559.

Wu, X., Yao, J. 2012. Understanding the rise and decline of the Japanese main bank system: The changing effects of bank rent extraction. Journal of Banking & Finance 36, 36–50.

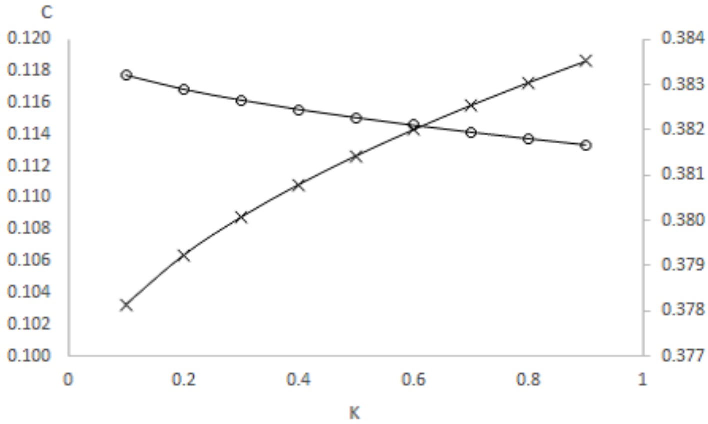
Yun, H. 2009. The choice of corporate liquidity and corporate governance. Review of Financial Studies 22, 1447–1475.

Figure 1: Lender's effect on the corporate investments



Notes: Upper figure depicts the budget constraint when the firm is less constrained (λ small) and when it is more constrained (λ large). Lower figure depicts that the optimal point changes from A to B. The optimality condition is given by Eq. (8). These figures assume that the profitability aggravates.

Figure 2: Simulated results: Lender's capital and corporate cash holdings



Notes: Upward sloping curve represents the simulated optimal cash and lender's capital when the profitability improves. Downward sloping curve corresponds to when the profitability aggravates. Parameters are: $c_0 = 1$, $E(c_1) = 0.5$, $q = 0.9$, $\gamma = 1.1$, $\theta = 0.95$, $b = 0.1$, $\Delta\theta = 0.1$, and $\phi = 0.5$. $\alpha_0 = 0.5$, $\alpha_1 = 0.6$ for upward curve and $\alpha_0 = 0.5$, $\alpha_1 = 0.4$. Left vertical axis is for downward sloping curve and right one for upward sloping one.

Table 1: Summary statistics

	Asset-constrained firms	Payout-constrained firms	Firms without access to bond markets
Firm variables			
Cash holdings (%)	13.47	10.41	11.61
	(8.364)	(6.990)	(7.658)
Cash flow (%)	5.873	4.563	6.730
	(5.219)	(4.353)	(5.148)
Tobin's q	0.961	0.959	0.972
	(0.337)	(0.220)	(0.300)
Short-term debt (%)	-0.921	-0.903	-0.751
	(8.089)	(6.979)	(7.174)
Leverage	2.211	3.627	3.084
	(5.175)	(9.382)	(22.73)
Size	9.453	10.99	10.48
	(0.518)	(1.506)	(1.080)
Investment growth dummy	0.609	0.596	0.617
	(0.488)	(0.491)	(0.486)
Lender variables			
Capital ratio (%)	12.08	12.71	12.52
	(2.707)	(2.979)	(2.965)
Liquidity ratio (%)	4.877	4.819	4.838
	(1.910)	(1.837)	(1.874)
Number of obs.	3,451	3,144	6,088

Notes: This table presents means and standard deviations of the variables for asset-constrained firms, payout-constrained firms and firms without access to bond markets, respectively. Definition of variables are in Appendix. Asset-constrained firms are defined as the firms with asset size in the bottom three deciles of the original sample. Payout-constrained firms are defined as the firms with payout ratios in the bottom three deciles. Five variables (Cash holdings, Cash flow, Short-term debt, Lender's capital ratio, and Lender's cash ratio) are represented as percentages only in this table. Standard deviations are in parentheses.

Table 2: Lender's effects in cash holdings of non-financial firms: IV-GMM estimation Panel A: Asset-constrained firms

Dependent variable: ΔCashholdings ratio of non-financial firms

Model	(1)	(2)	(3)	(4)
Subsample (Investment growth)	positive	negative	positive	negative
Main variables				
Cash flow	0.118***	0.353***	0.101**	0.331***
	(0.040)	(0.099)	(0.051)	(0.084)
Lender's capital ratio	0.087*	-0.097*	0.092*	-0.113**
	(0.048)	(0.049)	(0.049)	(0.051)
Control variables				
Q	0.020**	-0.016*	0.017*	-0.019**
	(0.008)	(0.009)	(0.010)	(0.008)
Short-term debt			-0.041	0.004
			(0.049)	(0.073)
Leverage			-0.001	-0.002
			(0.001)	(0.001)
Size			-0.006	-0.002
			(0.006)	(0.007)
Constant	-0.035***	0.004	0.028	0.033
	(0.011)	(0.010)	(0.058)	(0.071)
Observations	2,101	1,533	2,101	1,533
Number of firms	652	545	652	545
Sargan test	434.6	312.1	271.3	313.1
p-value	0.000	0.000	0.000	0.000
Hansen test	225.4	157.1	128.6	151.9
p-value	0.146	0.371	0.347	0.419
Chi squared test (all coeffs are zero)	21.73	13	19.63	30.57
p-value	0.000	0.005	0.003	0.000

Table 2 (Continued)
Panel B: Payout-constrained firms
Dependent variable: ΔCashholdings ratio of nonfinancial firms

Model	(1)	(2)	(3)	(4)
Subsample (Investment growth)	positive	negative	positive	negative
Main variables				
Cash flow	0.149***	0.203**	0.115***	0.182*
	(0.043)	(0.093)	(0.043)	(0.110)
Lender's capital ratio	0.060*	-0.252***	0.067*	-0.209**
	(0.034)	(0.093)	(0.040)	(0.096)
Control variables				
Q	0.020**	-0.020*	0.019	-0.015
	(0.010)	(0.012)	(0.012)	(0.011)
Short-term debt			-0.045	0.088***
			(0.039)	(0.031)
Leverage			-0.000	-0.001
			(0.001)	(0.001)
Size			-0.001	0.000
			(0.001)	(0.001)
Constant	-0.034***	0.039**	-0.023	0.034**
	(0.011)	(0.016)	(0.014)	(0.015)
Observations	1,875	1,369	1,875	1,369
Number of firms	767	651	767	651
Sargan test	330.9	297.1	212.1	273.5
p-value	0.000	0.000	0.000	0.000
Hansen test	183.5	184.6	125.9	181.5
p-value	0.052	0.710	0.031	0.714
Chi squared test (all coeffs are zero)	19.52	11.65	14.92	13.95
p-value	0.000	0.009	0.021	0.030

Table 2 (Continued)
Panel C: Firms without bond market access
Dependent variable: ΔCashholdings ratio of nonfinancial firms

Model	(1)	(2)	(3)	(4)
Subsample (Investment growth)	positive	negative	positive	negative
Main variables				
Cash flow	0.122***	0.164***	0.113***	0.161***
	(0.021)	(0.038)	(0.023)	(0.041)
Lender's capital ratio	0.043**	-0.220***	0.060**	-0.233***
	(0.021)	(0.071)	(0.025)	(0.076)
Control variables				
Q	0.003	-0.001	0.004	0.001
	(0.004)	(0.007)	(0.004)	(0.007)
Short-term debt			-0.074*	0.061***
			(0.044)	(0.018)
Leverage			-0.000	0.000
			(0.000)	(0.000)
Size			-0.002	-0.000
			(0.001)	(0.001)
Constant	-0.016***	0.015	0.003	0.017
	(0.005)	(0.011)	(0.013)	(0.011)
Observations	3,754	2,335	3,754	2,335
Number of firm	1,248	930	1,248	930
Sargan test	237.8	397.3	208.2	384.5
p-value	0.000	0.000	0.000	0.000
Hansen test	131.5	249.3	121	244.7
p-value	0.019	0.554	0.050	0.582
Chi squared test	43.97	28.42	50.28	37.61
p-value	0.000	0.000	0.000	0.000

Notes for Table 2: Each panel uses the different sample. The sample of panel A is asset-constrained firms, payout-constrained firms in panel B, and firms without bond market access in panel C. Asset-constrained firms are defined as the firms with asset size in the bottom three deciles of the original sample. Payout-constrained firms are defined as the firms with a payout ratio in the bottom three deciles. In each panel, odd columns show the results for positive growth of investment and even columns show the results for the negative growth of investment. Definitions of variables are in Appendix. The models are estimated by two-step GMM. Heteroscedastic robust standard errors are in parentheses. ***, ** , and * indicate significance at 1%, 5%, and 10% level respectively. Chi-squared statistics testing that all coefficients are zero are reported.

Table 3: Lender's liquidity effects in cash holdings of non-financial firms: IV-GMM estimation

Dependent variable: ΔCashholdings ratio of non-financial firms

Model	(1)	(2)	(3)	(4)	(5)	(6)
Financial constraints	Asset-constrained		Payout-constrained		Firms without bond market access	
Subsample (Investment growth)	positive	negative	positive	negative	positive	negative
Main variables						
Cash flow	0.108**	0.204***	0.098***	0.158***	0.096**	0.118***
	(0.053)	(0.077)	(0.034)	(0.049)	(0.045)	(0.045)
Lender's liquidity ratio	0.148*	-0.165*	0.140*	-0.149**	0.180*	-0.162*
	(0.089)	(0.086)	(0.075)	(0.064)	(0.105)	(0.086)
Control variables						
Q	0.022**	0.008	0.007	-0.008	0.002	0.005
	(0.011)	(0.011)	(0.010)	(0.006)	(0.006)	(0.006)
Short-term debt	0.058	0.098***	0.047***	0.096***	-0.034	0.022
	(0.036)	(0.024)	(0.018)	(0.029)	(0.034)	(0.040)
Leverage	-0.000	-0.002	-0.000	-0.001	0.000	-0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
Size	-0.003	-0.005*	-0.001	0.000	-0.011**	-0.009
	(0.006)	(0.003)	(0.001)	(0.001)	(0.005)	(0.007)
Constant	-0.005	0.037	-0.006	0.007	0.094*	0.090
	(0.059)	(0.027)	(0.011)	(0.012)	(0.049)	(0.070)
Observations	2,101	1,350	1,875	1,270	3,754	2,335
Number of firms	652	486	767	614	1,248	930
Sargan test	236.2	490.2	302.5	425.3	470.5	156.9
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Hansen test	129.5	365.6	149.8	298.6	194.6	103.7
p-value	0.167	0.466	0.138	0.201	0.015	0.154
Chi squared test	23.32	32.88	27.19	23.10	25.49	27.90
p-value	0.000	0.000	0.000	0.000	0.000	0.000

Notes for table 3: The sample is asset-constrained firms in columns (1) and (2), payout-constrained firms in columns (3) and (4), and firms without bond market access in columns (5) and (6). Asset-constrained firms are defined as the firms with asset size in the bottom three deciles of the original sample. Payout-constrained firms are defined as the firms with a payout ratio in the bottom three deciles. The subsamples are firms with positive growth of investment in odd columns and those of negative investment growth in even columns. Definitions of variables are in Appendix. The models are estimated by two-step GMM. Heteroscedastic robust standard errors are in parentheses. ***, ** , and * indicate significance at 1%, 5%, and 10% level respectively. Chi-squared statistics testing that all coefficients are zero are reported.

Table 4: Robustness check: Alternative definition of constraints

Dependent variable: ΔCashholdings ratio of nonfinancial firms

Model	(1)	(2)	(3)	(4)
Financial constraints	Asset-constrained		Payout-constrained	
Subsample (Investment growth)	positive	negative	positive	positive
Main variables				
Cash flow	0.201***	0.433***	0.141***	0.180*
	(0.060)	(0.130)	(0.052)	(0.105)
Lender's capital ratio	0.094*	-0.388***	0.075**	-0.198**
	(0.051)	(0.134)	(0.034)	(0.094)
Control variables				
Q	0.026***	-0.021*	0.012	-0.028
	(0.009)	(0.012)	(0.011)	(0.021)
Constant	-0.046***	0.038**	-0.028**	0.040*
	(0.011)	(0.019)	(0.013)	(0.023)
Observations	2,078	1,561	2,074	1,526
Number of firms	584	506	500	453
Sargan test	394.4	333.7	331.3	170.4
p-value	0.000	0.000	0.000	0.000
Hansen test	185.6	157.9	208.4	103.2
p-value	0.259	0.236	0.002	0.367
Chi squared test	36.04	15.76	14.43	6.447
p-value	0.000	0.001	0.002	0.092

Notes for table 4: In this table, constrained firms are identified based on time-series averages of each firm by each criterion. The sample is asset-constrained firms in columns (1) and (2) and payout-constrained firms in columns (3) and (4). Asset-constrained firms are defined as the firms with asset size in the bottom three deciles of the original sample. Payout-constrained firms are defined as the firms with a payout ratio in the bottom three deciles. The subsamples are firms with positive growth of investment in odd columns and those of negative investment growth in even columns. Definitions of variables are in Appendix. The models are estimated by two-step GMM. Heteroscedastic robust standard errors are in parentheses. ***, ** , and * indicate significance at 1%, 5%, and 10% level respectively. Chi-squared statistics testing that all coefficients are zero are reported.

Appendix A: Definitions of variables

Table A1: Definition of variables

Firm variables	
Cash holdings	Sum of cash and deposit (cash equivalents) scaled by book asset
Cash flow	Sum of ordinary income and depreciation scaled by book asset
Tobin's Q	Ratio of market value to book asset
Short-term debt	Change in short-term debt scaled by book asset
Leverage	Ratio of liability minus cash to asset minus liability
Size	Logarithm of book asset
Investment growth dummy	takes 1 if the firm's investment grows and 0 otherwise
Payout ratio	Sum of dividends of common equities and share repurchase scaled by book asset
Lender's variables	
Capital ratio	Regulatory capital ratio of the primary lender of the firm
Liquidity ratio	Sum of cash and deposit ratio of the primary lender of the firm

Appendix B: Comparative statics results[Not to be published]

This appendix provides calculations around Eq. (20). First, from the definition of $\lambda = 1 - q\phi x$, $d\lambda/dx = -q\phi$. Second, totally differentiating Eq. (8), we have

$$\frac{dC^*}{d\lambda} = -\frac{I_0 g''}{f'' + g''}\left(\frac{f''}{g''} - \frac{I_1}{I_0}\right) \tag{24}$$

From these two, we have Eq. (20). This equation reduces to

$$\frac{dC^*}{d\lambda} = \frac{I_1 g''}{f'' + g''}\frac{\alpha_1 - \alpha_0}{\alpha_1 - 1} \begin{array}{ll} > 0 & \text{if} \quad \alpha_1 < \alpha_0 \\ < 0 & \text{if} \quad \alpha_1 > \alpha_0 \end{array} \tag{25}$$

Third, from the first order condition with respect to investments, we have

$$\alpha_0 I_0^{\alpha_0 - 1} = \alpha_1 I_1^{\alpha_1 - 1} \tag{26}$$

Rewriting this, we have

$$\ln\left(I_0^{\alpha_0-1}/I_1^{\alpha_1-1}\right) = \ln(\alpha_1/\alpha_0) > \ln_e 1 \quad \text{if} \quad \alpha_1 > \alpha_0 \tag{27}$$

Then, we have

$$\frac{\ln(I_1)}{\ln(I_0)} > \frac{\alpha_1 - \alpha_0}{1 - \alpha_1} > 1 \quad \text{if} \quad \alpha_1 > \alpha_0 \tag{28}$$

The opposite inequality holds if $\alpha_1 < \alpha_0$. Therefore, $I_1 > I_0$ holds if and only if $\alpha_1 > \alpha_0$ holds, vice versa. Lastly, we combine these three and derive

$$\frac{dC^*}{dx} \begin{array}{ll} > 0 & \text{if} \quad \alpha_1 > \alpha_0 \\ < 0 & \text{if} \quad \alpha_1 < \alpha_0 \end{array} \tag{29}$$

Appendix C: Numerical example of theoretical model

This appendix demonstrates the model in a numerical example. We assume that the cost of monitoring investment is quadratic, i.e., $\psi = x^2/2$, in addition to Cobb-Douglas production function assumption in the text.

A firm's first order condition (8) becomes

$$\alpha_0 \left(\frac{c_0 - C}{\lambda}\right)^{\alpha_0 - 1} = \alpha_1 \left(\frac{E(c_1) + C}{\lambda}\right)^{\alpha_1 - 1} \tag{30}$$

Since Eq. (13) is binding at the optimum,

$$B^* = \gamma^{-1} q\phi x^* I \tag{31}$$

Substituting this into Eq. (18), we have

$$n^* = \frac{\gamma K}{(1 - \theta(\gamma - b/\Delta\theta))\, q\phi x I} \tag{32}$$

The first order condition for lender's monitoring investment Eq. (17) becomes

$$x^* = (\theta\gamma - 1) n^* \gamma q \phi I. \tag{33}$$

Substituting Eq. (32) into this, we have

$$x^* = \gamma \sqrt{\frac{(\theta\gamma - 1)K}{1 - \theta(\gamma - b/\Delta\theta)}} \tag{34}$$

Therefore x^* is increasing in K if $\theta\gamma > 1$ and $1 > \theta(\gamma - b/\Delta\theta)$. From the definition of λ, we have

$$\lambda^* = 1 - \phi q \sqrt{\frac{(\theta\gamma - 1)K}{1 - \theta(\gamma - b/\Delta\theta)}} \tag{35}$$

Substituting this into Eq. (30), we derive the optimal cash holdings C^*.

Now we set parameter values as follows: $c_0 = 1$, $E(c_1) = 0.5$, $q = 0.9$, $\gamma = 1.1$, $\theta = 0.95$, $\alpha_0 = 0.5$, $\alpha_1 = 0.9$, $b = 0.1$, $\Delta\theta = 0.1$, and $\phi = 0.5$. The following table provides the values of endogenous variables when lender's capital is $K = 0.4$ and 0.5.

K	0.400	0.800
C^*	0.696	0.703
λ^*	0.937	0.910
I_0^*	0.324	0.326
I_1^*	1.278	1.322
B_0^*	0.021	0.029
B_1^*	0.081	0.119
n^*	4.348	5.977
x^*	0.155	0.219

Appendix D: Distribution of financially constrained firms

	Asset-constrained	Payout-constrained	Firms without access to bond market	Others
Asset-constrained		934	2,431	86
Payout-constrained	934		1,645	566
Firms without access to bond market	2,431	1,645		2,013