TCER Working Paper Series

Passive and Proactive Motivations of Cash Holdings

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March 2024

Working Paper E-200
https://www.tcer.or.jp/wp/pdf/e200.pdf

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Abstract

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This version: March 3, 2024

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Keywords: Cash holdings; precautionary motive; investment opportunity

JEL Classification: G30, G31, G32

* We are grateful to Robert Hill, Takatoshi Ito, Tokuo Iwaisako, Hidehiko Matsumoto, Tsutomu Miyagawa, Shinichi Nishiyama, Tomiki Oshika (discussant), Etsuro Shioji, Miriam Steurer, Ichiro Uesugi and other participants in SWET 2023 and AEAJ 2023 Autumn. This work was supported by the Japan Society for the Promotion of Science (JSPS) under Grant No. JP21H00728 and JP21H04394. The views expressed herein are those of the authors and should not be attributed to the IMF, its Executive Board, or its management.

1 Introduction

Cash holdings have long been a central topic in economic research, ranging from the seminal work of Keynes (1936) to contemporary studies. The core question to be solved is intriguing: Given that cash per se does not yield a positive net present value and incurs opportunity costs, why do many managers attempt to accumulate significant cash on their hand? This question has prompted numerous studies, each of which offers various theories explaining the motives behind corporate cash holdings. However, despite extensive research, there is no consensus among scholars on this issue.

Our discussion begins by presenting a notable fact, which we call the V-shaped relationship, between firms' growth opportunities and cash holdings in a sample of Japanese listed firms. Specifically, we find that cash holdings are positively correlated with growth opportunities in firms experiencing positive growth but negatively correlated with those facing adverse growth opportunities. As detailed in Section 4 and Figure 1, we find this nonlinear link irrespective of the chosen proxies for corporate growth opportunities and control variables. This divergent link suggests that the motivation for cash holdings varies between these two types of firms.

To account for this "V-shaped relationship," our study offers a novel interpretation of the precautionary motive in corporate cash holdings. We posit that firms accumulate cash as a cushion against negative productivity shocks, and concurrently as a means of ensuring flexible capital availability to seize future growth opportunities. This dual rationale provides a nuanced understanding of the strategic role of cash holdings in corporate finance.

We develop a numerical model that allows managers to optimally determine the levels of investment and cash holdings in response to shocks affecting the corporate production process. A unique aspect of this model is its consideration of the passive and proactive motives behind cash holdings. On the one hand, cash serves as a cushion against a negative shock by covering potential negative profits and resulting shortage of working capital. On the other hand, cash allows the mobilization of agile money to seize future positive growth opportunities. The growth opportunities include investments for research and development (R&D) and a merger and acquisition (M&A), which require availability of timely and secured capital when opportunities arrive. Through the careful calibration of each parameter, the model successfully replicates the V-shaped relationship between investment opportunities and cash holdings. Notably, in another scenario, where the model excludes the latter motive of cash holdings (endogenous growth opportunities), a linear negative relationship emerges, in contrast to the V-shaped pattern observed otherwise.

Furthermore, we examine the recent rise in corporate cash holdings through the lens of our model, which we believe provides general insight into corporate cash holdings. Corporate cash holdings among Japanese firms have been in an upward trend with a notable increase after the global financial crisis (GFC). To investigate the causes of this trend, we feed into the model two secular shifts after the GFC—the tightening of borrowing constraints and decline in interest rates—and analyze their impacts on corporate cash holdings. We find that a tighter borrowing constraint leads to a steeper V-shaped link, as it makes internal resources (cash) more valuable than external financing. This channel explains half of the increase in average corporate cash holdings after the GFC. By contrast, a decline in interest rates implies a lower opportunity cost of holding cash and, therefore, higher cash holdings, but the quantitative impact is modest. This result contrasts with those of previous studies, many of which highlighted the relevance of a low-interest-rate environment after the GFC. Overall, the tightening of a borrowing constraint and the decline in the interest rate account for 64% of the rise in the average cash holdings relative to the total assets net of cash after the GFC (6.6 percentage points out of 10.3 percentage point increase), whereas the model without a growth opportunity can explain merely 7% of the variation in the data.

Note that our model assumes that a manager maximizes a firm's value on behalf of shareholders and that cash holdings are a consequence of optimization. Another prevailing view is that cash holdings stem from the conflict between managers' and shareholders' incentives (e.g., Jensen, 1986). Although we do not preclude the possibility of comprehensively examining all the potential sources of agency friction, we extend the model to incorporate a simple form of agency conflict. Interestingly, the impact of agency frictions on cash holdings is ambiguous in our model because agency frictions may weaken the precautionary benefits of cash holdings while incentivizing managers to hold cash for their own interests. We find that, under a calibrated set of parameters, agency frictions do not substantively affect the V-shaped relationship, or they could even flatten the slope of the V-shape depending on the parameter values, suggesting the criticality of our baseline model's mechanism to account for the V-shaped relationship.

This study makes two contributions to the literature and to policy debates. First, it contributes to the literature on corporate cash holdings. Although there are numerous theoretical explanations for cash holdings, our finding of a V-shaped link between investment opportunities and cash holdings presents a novel challenge. To interpret this unique link, we extend the concept of the precautionary motive, suggesting that managers accumulate cash not only to protect against potential negative shocks, but also to prepare for positive investment opportunities. This expanded interpretation offers new insights into why firms hold larger cash reserves than was previously understood. Our findings contrast with those of Kakhbod et al. (2024), who identified a "U-shaped" relationship between cash holdings and firm size, attributing greater cash reserves in smaller and larger firms to financial constraints and business risk, respectively. Although there is a superficial similarity to our "V-shaped" relationship, this study is different from Kakhbod et al's (2024) study by focusing on investment opportunities and examining the cash *ratio* to operating assets in listed firms, as opposed to their focus on business dynamics and the cash *levels* in unlisted firms. We posit that our findings have broader implications for understanding corporate cash holdings, particularly in the context of larger listed firms with substantial investment opportunities that Kakhbod et al. (2024) did not cover.

Second, our study has implications for ongoing policy debates on corporate cash holdings. There has been considerable criticism of firms' "excessive" cash piles in Japan. The argument suggests that firms should utilize their cash reserves for capital investment to foster growth and profitability, or alternatively distribute excess cash to employees and shareholders (WSJ, 2013, 2014). Similar discussions take place in tax policies, such as the tax on excess retention in South Korea and similar debates in Japan and China (Kim, S. et al., 2023; WSJ, 2014), as well as historical and contemporary U.S. policies, such as the undistributed profits tax (UPT) of 1936, the American Jobs Creation Act (AJCA) of 2004, and the Tax Cuts and Jobs Act (TCJA) of 2017. These policies motivate managers to actively cycle cash back into the economy. However, our findings suggest a more nuanced reality: optimal managerial strategies (aligned with shareholder interests) may involve cash accumulation in scenarios characterized by extremely low or high investment opportunities. This indicates that substantial cash reserves are not inherently indicative of inefficient managerial decision making.

The remainder of this paper is organized as follows. Section 2 provides an overview of related studies. Section 3 describes the data source and sample construction process. Section 4 reports stylized facts about cash holdings after the 2000s. This section describes the V-shaped relationship between investment opportunities and cash holdings. Section 5 describes the regression analysis, and reports the results. Section 6 develops our model to explain the V-shape, then calibrates the parameters and reports the results of our model. This section discusses the qualitative implications of our model and examines agency conflicts too. Finally, Section 7 concludes the study.

2 Literature review

2.1 Fact findings on cash holdings across the globe

Rising corporate cash holdings have been widely reported in advanced economies. Over the past few decades, US firms have shown a trend of increasing cash accumulation. Bates et al. (2009) show that the median cash ratio to total assets in US firms rose from 5.5% in 1980 to 13.3% in 2006. Begenau and Palazzo (2021) find an increase in the average cash-to-total assets ratio from 8% in 1979 to 25% in 2013.

This trend, as indicated by Graham and Leary (2018) and Pinkowitz et al. (2016), has been consistent from the late 1970s to the 2010s.

This phenomenon also occurs outside the US. Ferreira and Vilela (2004) find that, in the early 2000s, cash holdings in continental European firms accounted for approximately 15% of total assets. Brufman et al. (2013) examine 5,000 listed manufacturing companies in Germany, France, Italy, Japan, and the UK from 1997 to 2011 and find a common trend of declining capital investment and increasing corporate savings. Gruber and Kamin (2015) note a more pronounced tendency for firms in major countries to hold cash after the 2007–2009 global recession, particularly among growing ICT companies. More recently, Fahlenbrach et al. (2021) examine the impact of the coronavirus disease (COVID-19) pandemic on corporate financing, focusing on differences in liquidity holdings.

The propensity of Japanese firms to maintain substantial cash reserves on balance sheets is well documented. Kusnadi and Wei (2011) show that, between 1995 and 2004, Japanese firms had an average cash-to-total assets ratio of 16.07%, the highest among the 39 countries studied. Similarly, Riddick and Whited (2017) report that Japanese firms led the average cash-to-total assets ratio compared with their counterparts in the US, the UK, France, and Germany during 1994–2005. Kato et al. (2017) noted that in the early 1990s, the average cash ratio among Japanese firms surpassed that of US firms. This assertion is further supported by the findings of Sher (2014) and Kim, H. B. et al. (2023).

The increase in cash holdings worldwide has led to a convergence in the average cash ratios of Japanese and non-Japanese firms. Kato et al. (2017) observe that since the late 1990s, the cash-to-total assets ratio of US firms has surpassed that of Japanese firms. Although Japanese firms continue to exhibit higher pure cash ratios than their US counterparts, the margin of difference has been steadily decreasing, a trend particularly noticeable until the early 2010s. This observed convergence is explored by Kato et al. (2017) through improvements in corporate governance structures within Japanese firms associated with a decrease in cash holdings and an increase in dividend payout ratios.

2.2 Explanations

The precautionary motive is widely recognized as a fundamental factor explaining corporate cash holdings.[1] This explanation begins with the lack of sufficient capital to continue corporate activities under uncertainty because of their limited ability to raise external capital or of its higher premium (Myers, 1984). This provides companies an incentive to hold cash and deposits as readily available highly liquid assets to secure their future survival and investment opportunities. Consequently, this motive can be partially attributed to the rationale for cash accumulation as it potentially enhances shareholder value.

In this context, uncertainty manifests in two primary forms: negative demand shocks and positive investment shocks. In the first strand, Keynes (1936) argues that cash reserves enable managers to hedge against the risk of future cash shortfalls, providing a safety net in the case of unexpected events such as economic downturns or unexpected expenses. Lins et al. (2010) survey chief financial officers (CFOs) worldwide and show that they use their accumulated cash to hedge against negative cash flow shocks, especially during bad times. Fujitani et al. (2023) find that managers accumulate greater amounts of cash when they face economic policy uncertainty. Previous studies propose numerical models that justify cash holdings with precautionary motives for negative shocks. Armenter and Hnatkovska (2017) develop a general equilibrium model that features cash holdings stemming from the motive to build a buffer in the case of liquidity needs. Khan and Senga (2019) show that cash holdings are increasing in uncertainty and build a model that replicates this relationship through corporate default probabilities.

In the second strand of uncertainty, accumulated cash enables managers to invest in value-

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[1] We focus on precautionary motive of cash holdings, but also notice that there are other explanations: transaction motive (Baumol, 1952; Miller and Orr, 1968), agency problem (Jensen 1986), tax-based motive (Faulkender et al., 2019; Foley et al., 2007; Graham and Leary, 2018), intangibles (Begenau and Palazzo, 2021; Falato et al., 2022; He and Wintoki, 2016; Lei et al., 2018; Lyandres and Palazzo, 2016; Zhao, 2020), ammunition motive (Nyborg and Wang, 2021), and opportunity costs (Azar et al., 2016; Eskandari and Zamanian, 2022). In Section 6.5, we investigate impacts of agency problem in our model analysis.

enhancing projects without additional costs or delays. Prior studies show that managers tend to hold more cash when cash flows negatively correlate with investment funding needs (Acharya et al., 2007; Cunha and Pollet, 2020; Faulkender et al., 2019; Favara et al., 2021). Another strand of research shows a positive relationship between investment uncertainty and cash holdings (Martin and Santomero, 1997; Boyle and Guthrie, 2003; Bates et al., 2009; Harford et al., 2014; Alfaro et al., 2022). Similarly, Gao and Zhao (2022) build a quantitative equilibrium model featuring R&D and find that innovation uncertainty is the main driver of cash holdings in high-tech firms. A line of literature reports a negative association between cash holdings relative to total assets and firm size and argues that small firms need a larger cash buffer as they tend to be financially constrained (e.g., Hadlock and Pierce, 2010; Kakhbod et al., 2024).

In Japan, multiple studies examine how precautionary motives explain cash holdings.[2] Hori et al. (2010) find that firms with high growth potential (high market value ratio) tended to hold cash and deposits before the 1990s. However, an analysis of the monetary easing period since 2000 reveals that this relationship has disappeared. Shinada and Ando (2013) report that a decline in the ease of bank borrowing increased cash holdings during the financial crisis after the burst of the bubble economy (1997–2000) and during the GFC (2008–2010). Oku et al. (2018) report that, from their interview survey, many respondents suggested precautionary motives, such as increasing liquidity holdings, owing to their experience of rapidly difficult fundraising in the past. Hosono et al. (2019) find heterogeneous motivations for holding cash across firms facing better business conditions, maintaining better financial positions, and those with precautionary saving motives. We summarize the various motives for cash holdings in a V-shaped relationship with growth opportunities, and analyze the rationale in a structural model.

[2] Many studies have focused on the relationship between firm-bank relationship and corporate cash holdings (Hori et al., 2010; Sasaki and Suzuki, 2019; Cui et al., 2020; Nakajima and Sasaki, 2016; Shikimi, 2019). In Section 6.4, we investigate impacts of credit constraint on outcomes derived from our benchmark model, which we interpret influence of a change in firm-bank relationship.

3 Data source and sample construction

Our primary sample consists of all firms listed on Japanese stock exchanges from 2000 to 2020. We obtain financial and stock price data for these firms from QUICK Astra Manager, a database that includes quarterly and annual financial reporting data, as well as daily stock market data. In constructing our primary sample, we excluded firms operating within the financial sector (classified under the Nikkei Medium Classification Industry Codes 47–52) and those not adhering to a 12-month accounting period. We also limit our observations to firms with non-missing data for the variables of interest. This methodology aligns our sample with the standards of prior research to ensure a robust and comprehensive dataset for analyzing corporate cash holdings. After applying these criteria, our final sample comprises 52,642 firm-year observations.

4 Stylized facts in the 2000s

We measure corporate cash holdings as the sum of cash and short-term securities scaled by total assets minus the sum of cash and short-term securities (*cash*). The numerator considers both cash and short-term securities to represent corporate liquidity. This measurement is consistent with prior studies on cash holdings (e.g., Bates et al., 2009) and provides a comprehensive measure of a firm's liquidity. To ensure the robustness of our results, we also use the ratio of cash to total assets minus the sum of cash and short-term securities ($cash^{only}$) as an alternative measure. The former treats short-term securities as easily sellable assets, whereas the latter focuses solely on pure cash as the only source of liquidity for firms. The denominators isolate operating assets from total assets, which provides us with a cash holdings ratio consistent with the theoretical model in Section 6.

Panel A of Figure 1 shows the trends of cash holdings in Japan. Panel B in Figure 1 shows a bin-scatter plot illustrating the correlation between investment opportunities and corporate cash holdings. The Y-axis in each figure represents the cash holdings variable (*cash*), whereas the x-axis denotes the proxies for investment opportunities. These proxies in Panels B-1, B-2, B-3, and B-4 are sales growth (*sg*), value added growth (Δva), profitability growth ($\Delta prof$), and Tobin's q (q), respectively. We use gross profit and operating profit reported on the income statement as proxies for value-added and profitability, respectively. Tobin's q is the sum of the fair values of shareholder equity and liabilities scaled by their book values. The dotted lines in each panel represent the boundaries between the positive and negative investment opportunities. The boundaries for each variable in Panels B-1 to B-3 are set to zero, whereas Tobin's q in Panel B-4 is set to one. The red line in each panel depicts the fitted linear regression line, estimated using Ordinary Least Squares (OLS), for positive and negative investment opportunity areas.

Each panel shows two distinct correlations between investment opportunities and cash holdings. To the left of the boundary (where firms have negative investment opportunities), the panels show a negative relationship between the two variables. Conversely, on the right side of the boundary (where firms have positive investment opportunities), the relationship becomes positive. This contrast suggests that the relationship between investment opportunities and cash holdings is contingent on the characteristics of the opportunity itself.

5 Regression analysis

5.1 Panel data regression

To elaborate on the findings in Section 4, we conducted a regression analysis using the following models:

$$cash_{it} = \alpha_1 x_{it-1} + \boldsymbol{\Gamma} \cdot \boldsymbol{w_{it}} + \varepsilon_{it}, \tag{1}$$

$$cash_{it} = \beta_1 x_{it-1} + \beta_2 x_{it-1} \times 1(x_{it-1} < 0) + \beta_3 1(x_{it-1} < 0) + \boldsymbol{\Gamma} \cdot \boldsymbol{w_{it}} + \boldsymbol{E} \cdot \boldsymbol{w_{it}} \times 1(x_{it-1} < 0) + \varepsilon_{it}, \tag{2}$$

where the dependent variable $cash_{it}$ represents the corporate cash holdings of firm i in period t. While the independent variable of interest in Model (1) is x_{it}, that in Model (2) is the interaction between x_{it} and 1(x_{it}

< 0). The continuous variable x_{it} represents firm growth: growth of sales, value added, and profits (*sg*, Δva, and $\Delta prof$, respectively). The dummy variable $1(x_{it} < 0)$ takes the value of 1 if the firm growth variable takes negative values. We also add a vector of control variables $\boldsymbol{w_{it}}$ to control for possible covariates in the determinants of cash holdings. Following Bates et al. (2009), we include firm size ($size_{it}$), operating cash flow (cf_{it}), financial leverage (lev_{it}), net working capital (nwc_{it}), capital expenditure ($capex_{it}$), R&D expenditure (rd_{it}), acquisition expenditure (acq_{it}), and a dividend payout dummy ($1(div_{it} > 0)$). We triangulate multiple levels of fixed effects: year, industry, and firm. The definitions of all variables are described in Table A1. Following the standard procedure in the literature, we winsorize all continuous variables at the 1% and 99% levels to mitigate the influence of outliers. We cluster standard errors at the firm level and present the significance of the two-tailed tests.

We estimate Model (1) for two subsamples: one comprising observations with negative growth ($x_{it} < 0$) and the other comprising observations with positive growth ($x_{it} > 0$). Coefficient α_1 captures the relationship between firm growth and corporate cash holdings in each subsample. We estimated Model (2) using the entire sample. Coefficient β_1 represents the relationship between firm growth and corporate cash holdings for positive growth observations ($x_{it} > 0$). Coefficient β_2 of the interaction represents the relationship between observations and negative growth ($x_{it} < 0$). If our findings are robust, even after controlling for possible covariates, coefficients β_1 and β_2 should be positive and negative, respectively. These results suggest that greater growth opportunities and shrinking risk both enhance management cash accumulation incentives.

5.2 Regression results

Table 1 presents the descriptive statistics of the variables used in the regression models. Table 2 shows the regression results. Columns 1 and 2 report the regression results using subsamples categorized on the basis of the signs of sales growth as negative and positive, respectively. In the negative growth subsample, the coefficient of sales growth is negatively significant, indicating that firms with less growth tend to hold more cash. Conversely, in the positive growth subsample, the corresponding coefficient is positively significant, suggesting that firms with higher growth tend to hold higher cash levels. These results highlight the differential cash holding behavior of firms based on their sales growth performance. Although a change in sales growth by one standard deviation (0.183) decreases cash holdings by 6.1% of the standard deviation of the cash-to-total assets ratio for the subsample with negative growth, the same amount of change in sales growth increases cash by 1.5% of the standard deviation of the cash-to-total assets ratio for the subsample with positive growth.

Columns 3–5 shows the estimation results of the interaction Model (2). Column 3 does not include any fixed effects, Column 4 includes industry and year fixed effects, and Column 5 includes firm and year fixed effects. In all specifications, the coefficients of sales growth are positively significant, indicating a positive relationship between firm growth and cash holdings. Additionally, the coefficients of the interaction terms are negatively significant, suggesting that the difference in the coefficients between the two subsamples is statistically significant. The coefficients in Column 5 suggest that while the change in sales growth by one standard deviation (0.1803) decreases cash holdings by 5.4% of the standard deviation of the cash to total assets ratio for the negative growth subsample, the same amount of change in sales growth increases cash by 2.0% of the standard deviation of the cash to total assets ratio for the positive growth subsample. These results imply that positive growth firms tend to hold more cash when experiencing greater growth, whereas negative growth firms tend to hold more cash when experiencing less growth. In other words, the relationship between firm growth and cash holdings differs depending on the growth direction.

Columns 6 and 7 use growth in value-added and profitability as proxies for corporate growth. The coefficients on sales growth are positively significant, indicating a positive relationship between firm growth and cash holdings. Additionally, the coefficients of the interaction terms are negatively significant, suggesting that the difference in the coefficients between the two subsamples is statistically significant. The coefficients in Column 6 (Column 7) suggest that while the change in value added (profitability) by one standard deviation (0.061 and 0.0443) decreases cash holdings by 4.5% (3.3%) of the standard deviation of the cash to total assets ratio for the subsample with negative growth, the same amount of change in sales growth increases cash by 3.3% (3.1%) of the standard deviation of the cash to total assets ratio for the subsample with positive growth.

These results hold when we use the ratio of the sum of cash and short-term securities to total assets ($cash^{only}$) as the dependent variable (Table 3). This finding supports the robustness of our results.

6 Model analysis

6.1 Model

This section presents a model that reconciles the empirical findings of previous sections. The model shares salient features with those of Armenter and Hnatkovska (2017), who investigated corporate (net) savings in a structural model, but differs in that it explicitly considers gross cash holdings and, most importantly, growth opportunities, resulting in endogenous changes in productivity. The model focuses on a manager, who operates a firm to produce and make investment and financing decisions, thereby determining cash holdings. Time is discrete. A firm combines capital k_t and labor l_t to produce final goods according to the Cobb-Douglas production function:

$$f(k_t, l_t, z_t) = z_t k_t^{\alpha} l_t^{1-\alpha-\eta}, \tag{3}$$

where the first term z_t is productivity, which is described in detail shortly. Parameters $\alpha > 0$and $\eta > 0$ determine factor shares. Capital follows the law of motion:

$$k_{t+1} = i_t + (1-\delta)k_t, \tag{4}$$

where $\delta > 0$ is the depreciation rate, whereas labor is hired in a spot market with wage rate w_t. The period profit is given by

$$\pi(k_t, z_t) = \max_{l_t}(1-\tau)(f(k_t, l_t, z_t) - wl_t - \delta k_t) \qquad (5)$$

where τ is the profit tax rate and w is the wage rate. Note that the capital stock level at the beginning of period k_t, is predetermined. A firm chooses labor l_t, after observing productivity z_t, to maximize its profit. The first-order condition yields:

$$\pi(k_t, z_t) = (1-\tau)\varphi(z_t)k_t, \qquad (6)$$

where:

$$\varphi(z_t) = w(1-\alpha-\eta)^{\frac{1}{\alpha+\eta}}(z_t/w)^{\frac{1}{\alpha+\eta}}\left((1-\alpha-\eta)^{-\frac{\alpha}{\alpha+\eta}}(z_t/w)^{\frac{\eta}{\alpha+\eta}} - 1\right) - \delta.$$

The manager makes investment decisions. The investment is financed by internal and external resources. Internal resources are the net worth accumulated in a firm, whereas external resources take the form of debt instruments. Let d_t and a_t be debt and cash holdings, respectively. The debt is subject to the following collateral constraints:

$$d_{t+1} \leq \theta k_{t+1} + a_{t+1}, \qquad (7)$$

where $0 < \theta < 1$ governs the tightness of the constraint and cash also serves as collateral without discounting. A manager maximizes lifetime utility:

$$V = \max_{c_t, \xi_t, a_{t+1}, k_{t+1}, d_{t+1}} E_t \left[\sum_{j=0}^{\infty} \left(\beta(1-\chi)\right)^j c_{t+j} \right], \tag{8}$$

subject to a flow of budget constraint:

$$\begin{aligned} c_t + k_{t+1} + a_{t+1} - d_{t+1} + g(i_t, k_t)k_t + \xi_t \\ \leq (1-\tau)\varphi(z_t)k_t + k_t + a_t - (1+r)d_t, \end{aligned} \tag{9}$$

and the borrowing constraint (7). In the objective function (8), the weight on the stream of consumptions $0 < \beta < 1$ is the subjective discount factor and another term $0 < 1 - \chi < 1$ is a survival probability. On the LHS of the budget constraint (9), the first term in the LHS $c_t \geq 0$ is consumption and the last term $\xi_t \geq 0$ is investment for growth opportunities, which we describe shortly. The fifth term $g(i_t, k_t)$ is an investment adjustment cost, which takes the functional form of $g(i_t, k_t) = \frac{\mu}{2}\left(\frac{i_t}{k_t}\right)^2$ with μ governing the scale of adjustment cost. The RHS of equation (9) represents the firm's net worth after earning the period profit, whereas the LHS describes the allocation of resources in the next period. Note that a manager's consumption c_t can be viewed as a dividend to shareholders. With this interpretation, the maximization problem is isomorphic to a manager maximizing a firm's value V on behalf of shareholders to the extent that the discount factor is identical between the manager and shareholders (i.e., no agency conflicts).

The FOCs for consumption, c_t, and debt, d_{t+1}, yield

$$1 = \beta(1-\chi)(1+r) + \lambda_{1t}, \tag{10}$$

where $\lambda_{1t} \geq 0$ is the Lagrangian for the borrowing constraint (7). Here we assume that interest rate is low enough for a firm to borrow, that is, $\beta(1-\chi)(1+r) < 1$. The assumption is standard as a firm has additional discounting for future due to the default probability, $0 < \chi < 1$, and thus is willing to borrow. It leads to $\lambda_t > 0$, which indicates, along with the complementary slackness condition, the borrowing constraint (7) holds with equality, i.e., $d_{t+1} = \theta k_{t+1} + a_{t+1}$.

A key innovation of our model compared to that of Armenter and Hnatkovska (2017) is the endogenous development of productivity z_t. We assume that a firm is born with productivity level z_0, and sporadically encounters a "growth opportunity" that improves its productivity. A growth opportunity could be a R&D investment that bears innovation, inducing investment to materialize it. Innovation can also arise from M&A through which technology and know-how are obtained externally. Previous studies have highlighted that internal resources, such as cash holdings, facilitate seizing such growth opportunities. As the outcomes of R&D are uncertain, and even if fruitful, the resulting intangible assets may not serve as collateral, loans are often infeasible for financing such investments. M&As should be conducted in an agile and confidential manner; thus, securing borrowing in advance may not be desirable. Therefore, we assume that investment for the opportunity ξ_t can be only paid by cash:

$$\xi_t \leq a_t, \tag{11}$$

This constraint provides a critical motive of cash holdings.

Additionally, following Armenter and Hnatkovska (2017), we consider a catastrophic negative productivity shock that induces cash holdings as a precautionary buffer. As we will explain shortly, we calibrate the catastrophic shock to replicate the firms' operating losses observed in the data. Cash outflows due to operating losses must be covered by the existing cash stock after paying the investment for a growth opportunity. The within-period liquidity constraint is given by

$$(1-\tau)\varphi(z_t)k_t \leq a_t - \xi_t. \tag{12}$$

The possibility of future losses incentivizes firms to hold cash as a precaution. These assumptions are based on the following productivity processes:

$$\ln z_{t+1} = \begin{cases} \ln z_t + \phi\left(\frac{\xi_t}{k_t}\right) + \epsilon_t, \;\; \epsilon_t \sim N(0,\sigma^2) & \text{with prob. } p_\xi \\ \ln z_t + \epsilon_t & \text{with prob. } 1 - p_\xi - p_\gamma \\ \underline{\gamma} & \text{with prob. } p_\gamma \end{cases}, \tag{13}$$

where $0 < p_\xi < 1$ and $0 < p_\gamma < 1$ are probabilities with which a firm encounters a growth opportunity and a catastrophic negative productivity shock, respectively. $\phi(\cdot)$ governs the productivity gain from investment opportunities, which takes a form of $\phi(\xi_t/k_t) = \phi_1 + \phi_2\sqrt{\xi_t/k_t}$. We assume that the size of investment should grow in firm size (k_t) for a certain productivity gain and the return is decreasing in investment, i.e., $\phi(\cdot)$ is concave in ξ_t/k_t. We also incorporate an exogenous productivity shock, ϵ_t. $\underline{\gamma} < 0$ is the catastrophic productivity shock. The timing of events and decisions are summarized in Figure 2.

Although we leave a numerical analysis for a fuller investigation, it would be useful to speculate on firms' motives for cash holdings. The FOCs for cash, a_{t+1}, and investment for growth opportunity, ξ_t, lead to:

$$\underbrace{1}_{\substack{\text{Cost of using}\\ \text{resources}}} = \underbrace{\beta(1-\chi)}_{\text{Asset return}} + \underbrace{\lambda_{1t}}_{\substack{\text{Easing borrowing}\\ \text{constraint}}} + \underbrace{\beta(1-\chi)\left\{-1+\beta(1-\chi)(1-\tau)E_t\left[\frac{\partial\varphi(z_{t+2})}{\partial z_{t+2}}\frac{\partial z_{t+2}}{\partial \xi_{t+1}}k_{t+2}(1+\lambda_{2t+2})\right]\right\}}_{\substack{\text{Raising productivity}\\ \text{and thereby profit}}}. \tag{14}$$

This equation determines the trade-off on cash holdings. The LHS represents the cost of using one unit of resource for cash holdings, whereas the RHS represents its benefits. The first term on the RHS is the present value of asset returns, which is less than one, as cash does not bear interest earnings. The second term, λ_{1t}, is the Lagrangian for the borrowing constraint, and thus indicates the value of easing the constraint by one unit. The third term arises from the endogenous determination of productivity. In other words, cash holdings provide room for investment in growth opportunities, thereby facilitating productivity growth and contributing to additional profits. Additional cash holdings are all the more valuable when the liquidity constraint is tight, as represented by the Lagrangian of the constraint (12), λ_{2t}. Note that the last term is in expectations. According to equation (14), a manager optimally chooses positive cash holdings ex ante. However, if risks, i.e., a growth opportunity, do not materialize, cash ends up with "hoarding" creating opportunity cost.

The latter two terms on the RHS are determined endogenously along with the other variables. In the second term, lower physical capital k_{t+1}, given the level of cash holdings, tightens the borrowing constraint, which increases the value of cash. This finding implies that smaller firms with less capital have stronger incentives to hold cash through this channel. Moreover, when a firm is hit by a negative productivity shock (i.e., negative growth) and willing to scale down production, the resulting tighter borrowing constraints lead to a higher value of cash holdings. However, higher physical capital has distinct effects throughout the third term. Larger production scales lead to greater gains from productivity growth in the third term, suggesting a complementarity between cash and physical capital. When a firm receives a positive productivity shock (i.e., positive growth), it is eager to increase its physical capital and liquidity simultaneously. A similar mechanism also works through the derivative term, $\partial\varphi(z_{t+1})/\partial z_{t+1}$. It is shown that the profit $\varphi(\cdot)$ is convex under reasonable parameter values, as intuitively higher z increases the production scale and the margin per unit, both of which have positive impacts on profit. Thus, firms with a higher productivity level, including those receiving a positive shock, have an incentive to accumulate liquidity. In sum, Condition (14) suggests that both positive and negative shocks and the resulting positive and negative growth may incentivize firms to hold more liquidity.

6.2 Calibration

The frequency is annual. The model parameters are calibrated according to Japanese macro-and microdata. The calibrated parameters are listed in Table 4. The parameters in the production functions, α and η, are calibrated according to the factor shares in the system of national accounts (SNA). Following Armenter and Hnatkovska (2017), an entrepreneur's rent, η is set as the share of dividend payments in the GDP (3.6% on average from 2000 to 2020). The labor share in the model is given by $1-\alpha-\eta$, which is 55.7% of the data. This pins down α at 0.407.[3] The depreciation rate δ is also obtained from the SNA. Capital stock excludes government capital and private residential real estate, but includes foreign direct investment, consistent with this assumption. The annual depreciation rate is calculated as 11.1% (δ= 0.111). The profit tax rate, τ, is set to 0.3 according to the effective corporate tax rate estimated by the Ministry of Finance. Entrepreneur's exit rate, χ, is set to 0. 0185 to match the average age of the listed firms recorded in the FQ data (54 years). The subjective discount rate β is set to match the capital-to-output ratio in the

[3] Following Hayashi and Prescott (2002), wage income is calculated as the sum of compensation of employees, 80% of operating surplus in non-housing noncorporate sector, 50% of indirect business taxes, and proportion of statistical discrepancy.

SNA (2.188). The borrowing interest rate, r, is calculated to satisfy $1 + r = 1/\beta$. The tightness of the borrowing constraint θ is calibrated to match the 5th percentile of the net financial assets (NFA, cash minus debt) relative to the total assets net of cash ($-(a_t - d_t)/k_t$ in the model) in the FQ data (0.54). Catastrophic shock is modeled as an adverse event once every 20 years on average ($p_\gamma = 0.05$). The size of the shock, χ, is set to match the 5th percentile of operating profits divided by the total assets net of cash in the FQ data (4.8%). The probability of an investment opportunity, p_ξ, and a parameter in the productivity process, θ_2, are calibrated at 0.35 and 0.30, respectively, to match the average sales growth (+4.3%) and cash holdings relative to the total assets net of cash (30.0%). θ_1 is assumed at zero. Note that the V-shaped relationship between sales growth and cash holdings was not targeted in the calibration. The standard deviation of the exogenous productivity shocks σ is set to 0.05 according to sales growth (0.18). The investment adjustment cost μ, is set to 0.5, following the estimates of Nikolov and Whited (2014). The initial productivity level, z_0, is calibrated such that $\varphi(z_0) = 0$.

The model is solved using the value-function iteration method. The value and policy functions are defined in a state space of $\{k_t, a_t, z_t, \mathbf{1}_{\xi t}\}$, where $\mathbf{1}_{\xi t}$ is an indicator variable that takes the value of one if a firm encounters a growth opportunity. Using policy functions, we conducted a stochastic simulation for a sufficiently large number of periods and firms.

6.3 Results

Figure 3 shows the simulation results of the model. The baseline model with endogenous investment opportunities, shown in Panel A, displays a clear V-shaped relationship between cash holdings and output growth. The presence of negative shocks, including catastrophic shocks, induces cash holdings. When current productivity is low, firms are willing to reduce their capital. However, they do not necessarily pay out resources such as consumption or debt repayment, as a low level of productivity implies a higher likelihood of negative profits if hit by further negative shocks, requiring holding cash as a buffer. Capital adjustment costs result in persistent reductions in investments in subsequent periods, leading to negative output growth. Thus, a negative association exists between cash holdings and growth in territories with negative output growth. By contrast, cash holdings create room for investment in growth opportunities. A firm that encounters a growth opportunity benefits from productivity improvement, and thus can secure internal resources for further cash holdings to seek future opportunities, as well as accumulate capital. A positive feedback loop leads to an upward relationship between cash holdings and growth in a positive territory. For comparison, we also simulate the model without investment opportunities in Panel B. It is natural to observe a uniform negative association in the absence of an endogenous investment opportunity.

On an average, endogenous investment opportunities result in higher cash holdings. The average cash-to-capital ratio is 16.6% without an endogenous investment opportunity and 30.0% in the baseline model. Liquidity holdings are "passive" without the endogenous investment opportunity in the sense that firms hold liquidity as a result of lack of investment demand. By contrast, with the endogenous channel of investment opportunities, cash holdings play an active role in facilitating investments in growth opportunities.

6.4 Drivers of rising cash holdings

What explains the sharp increase in Japanese firms' cash holdings after the GFC as shown in Panel A of Figure 1? We address this question through the model. Specifically, we feed into the model two secular shifts in the economy after the GFC and examine the model's capability to account for the overall increase in firms' liquidity holdings observed in the data. First, we considered tightening borrowing constraints. Although the Japanese financial system remained resilient during the GFC and firms' bankruptcy was kept low during this period, firms faced tightened lending stances by financial institutions and evaporated liquidity in bond and equity markets, which made them more conservative in their view of the availability of financing at the time of stress (e.g., Shinada and Ando, 2013). Moreover, strict financial regulations after the GFC limited risk-taking by banks and institutional investors, thereby tightening firms' borrowing constraints. In our dataset, the ceiling of borrowing, measured by the 5th percentile of the net borrowing ratio (NFA/total asset net of cash), declined from 0.66 in the pre-GFC period (2000–07) to 0.52 in the post-GFC period (2010–20). We interpret this change as a tightening of the borrowing constraint; that is, a lower θ in the model. Second, we explore the impact of the decline in interest rates. After the GFC, the average bank lending rate declined from 1.8% to 1.0%. We consider this decline as a change in the borrowing interest rate (r) in the model. Note that we abstract the impact of inflation dynamics on real interest rates; given that inflation remained close to zero over time. We confirmed in a background analysis that inflation affects both the real rate of return of liquidity holdings on the asset side and the real borrowing rate on the liability side, as a consequence of which the net impact is minor.

Panel A in Figure 4 shows that the tightening of the borrowing constraint leads to significantly steeper slopes in the V-shaped relationship between output growth and liquidity holdings in. In principle, tighter borrowing constraints increase the value of internal resources. Firms are incentivized to retain internal resources as liquidity holdings when they obtain them, either by achieving higher profits under positive growth or by reducing capital stock under negative growth conditions. High growth is particularly challenging in terms of liquidity management. Firms face a tradeoff in the use of profits between building capital stock to seize the benefits of high productivity and securing part of their profits as liquidity to seek future investment opportunities. A tighter borrowing constraint exacerbates this tradeoff, as the former need can be achieved by borrowing. Consequently, Figure 4 suggests that the average liquidity ratio is 4.7 percent points (p.p.) higher under tighter borrowing constraints. This explains approximately half the increase in the ratio after the GFC observed in the data (10.3 p.p.). By contrast, Panel B of Figure 4 indicates that the lower interest rate after the GFC provides a modest contribution to the change in the liquidity ratio. Table 5 suggests that the average liquidity ratio increases by 1.9 p.p. under the lower interest rate. Although the interest rate is a key parameter in determining the opportunity cost of holding cash, room for an additional decline in the interest rate was relatively limited, given the already low interest rate environment before the GFC in Japan.

These results provide a fresh perspective on the drivers of increasing liquidity holdings among Japanese firms. Several studies have emphasized the importance of interest rate changes, which serve as the opportunity cost of holding liquidity (Azar et al., 2016; Eskandari and Zamanian, 2022). Our model does not preclude that channel but suggests much smaller contributions than previously stated. Instead, our analysis supports the importance of borrowing constraints. A few studies have explored the implications of tighter lending conditions following the GFC. Our contribution is to demonstrate the quantitatively sizable impact of this channel, particularly through firms' incentives to secure internal resources and seize investment opportunities.

6.5 Agency problem

Our baseline model assumes that a manager's incentive is identical to that of shareholders; thus, solving the manager's optimization problem maximizes a firm's value. Cash holdings are optimally chosen because of the trade-off between costs and benefits. Another prevailing view is that conflicts between managers' and shareholders' incentives allow managers to accumulate internal resources, which are more controllable for managers under information frictions, even if they are value-decreasing (Jensen, 1986). In this section, we extend the model to incorporate agency conflicts and determine how agency problems potentially affect the relationship between growth opportunities and cash holdings. Specifically, we follow Nikolov and Whited's (2014) specification, whereby a manager's objective function discounts the firm's value and instead includes the manager's private payoff that arises from abusing part of the internal resources under limited monitoring by shareholders.[4] The objective function and constraints are modified

[44] Note that previous studies point out various sources of agency frictions. For instance, Grossman and Hart (1982) propose that agency frictions arise as bankruptcy is more costly for a manager than shareholders who have a diversified portfolio.

as follows:

$$\tilde{V} = \max_{c_t, \xi_t, a_{t+1}, k_{t+1}, d_{t+1}} E_t\left[\sum_{j=0}^{\infty}(\beta(1-\chi))^j\left\{s_1\left((1-\tau)\varphi(z_{t+j})k_{t+j} + a_{t+j}\right) + s_2 c_{t+j}\right\}\right], \tag{15}$$

$$\text{s.t.}\quad c_t + k_{t+1} + a_{t+1} - d_{t+1} + g(i_t, k_t)k_t + \xi_t \leq (1-s_1)(1-\tau)\varphi(z_t)k_t + k_t + (1-s_1)a_t - (1+r)d_t, \tag{16}$$

$$\xi_t \leq (1-s_1)a_t, \tag{17}$$

$$(1-\tau)\varphi(z_t)k_t \leq (1-s_1)a_t - \xi_t, \tag{18}$$

where a manager uses a fraction $0 < s_1 < 1$ of profits, $(1 - \tau)\ \varphi(z_t)k_t$, and cash, a_t, for his own interest, and discounts a fraction $0 < s_2 < 1$ of the firm's value in his objective function. To observe the effects of agency conflicts on cash holdings, we compare the optimal conditions with the baseline case. The FOC for cash holdings a_{t+1} (14) is modified as follows:

$$\underbrace{1}_{\text{Cost of using resources}} = \underbrace{\beta(1-\chi)\left(1 + s_1\left(\frac{1}{s_2} - 1\right)\right)}_{\text{Asset return}} + \underbrace{\frac{1}{s_2}\lambda_{1t}}_{\text{Easing borrowing constraint}} + \underbrace{\beta(1-\chi)(1-s_1)\left\{-1 + \beta(1-\chi)(1-\tau)\left(1 + s_1\left(\frac{1}{s_2} - 1\right)\right)E_t\left[\frac{\partial\varphi(z_{t+2})}{\partial z_{t+2}}\frac{\partial z_{t+2}}{\partial \xi_{t+1}}k_{t+2}\right]\right\}}_{\text{Raising productivity and thereby profit}}. \tag{19}$$

The benefit of the asset return on cash (the first term on the RHS) and profit (the third term) is scaled up by $(1 + s_1\ (1 / s_2 - 1)) > 1$ because of the manager's private gain from cash and profits. This would facilitate more cash holdings if the other conditions remain unchanged. However, the last term is discounted by $(1 - s_1) < 1$, which can reduce the benefits of cash holdings. This arises from the cash discounting in constraints (17) and (18). The fraction of private cash use, $1 - s_1$, cannot be used for the intrinsic purposes of cash holdings; that is, to provide a buffer for a negative shock and facilitate the seizing of growth opportunities. Consequently, the total impact of agent conflicts on cash holdings is ambiguous ex-ante in our model. This implication differs from that obtained in a standard model with agency frictions, in which the presence of frictions increases cash holdings.

Acknowledging the challenge of estimating the degree of agency conflict from the data, we provide numerical examples under the calibrated parameters of s_1 and s_2. Nikolov and Whited (2014) estimate a structural model of U.S. firm data and obtain $s_1 \times 1{,}000 = 0.101$ and $s_2 = 0.051$. Figure 5 indicates that under these parameter values, agency conflicts have little impact on the V-shaped relationship between growth opportunities and cash holdings or average cash holdings. We further check the sensitivity with respect to the parameter values. When s_2 is reduced to 0.051/20, the average cash holdings increase substantially, but the slope of the V-shaped relationship becomes considerably flatter. This is because the manager's motive for the private use of cash and profits is not strictly linked to growth opportunities, and the marginal impact of agency conflicts increases when the cash holdings motive for a firm's value maximization is relatively low. In the background analysis, we find that a higher s_1 decreases cash holdings, which is consistent with the aforementioned prediction and modestly flattens the slope of the V-shaped relationship. Overall, the analyses imply that the presence of agency conflicts does not alter the main results.

7 Conclusion

In this study, we showed a "V-shared relationship" between investment opportunities and cash holdings: cash holdings are positively correlated with investment opportunities in firms experiencing positive investment scenarios, but negatively correlated in those facing adverse investment opportunities. This divergent link suggests that the motivation for cash holdings varies between these two types of firms.

To account for this V-shaped relationship, we developed a numerical model that allows managers to optimally determine the levels of investment and liquidity (cash) holdings in response to both negative and positive shocks affecting the corporate production process. The model highlights the positive motives for cash holdings. In other words, cash enables managers to promptly provide money to finance profitable investment opportunities. Together with the conventional interpretation of precautionary motives in which cash serves as a buffer against negative shocks, the model successfully replicates the V-shaped relationship between investment opportunities and cash holdings. Furthermore, we examined the factors that influence this relationship by focusing on borrowing constraints and interest rates. We found that the magnitude of the borrowing constraint leads to a steeper V-shaped link, whereas variations in interest rates do not significantly alter the slope. These findings suggest that the V-shaped dynamic is particularly pronounced under conditions of stringent financial constraints but remains relatively unaffected by fluctuations in interest rates. Given the tightening of borrowing constraints after the GFC, the model accounts for approximately half of the increase in corporate cash holdings after that period.

It is important to note a caveat of our study. Our baseline model rules out other possible explanations, particularly those related to agency conflicts. We argue that corporate cash holdings can be understood, even in the absence of agency conflicts between shareholders and managers. Although we verify that a simple form of agency conflict does not alter our main results, it remains an open question whether our model's mechanism can coexist with other potential reasons for cash holdings and how they interact with each other. In this context, our aim is to offer a new perspective on the rationale behind corporate cash holdings rather than exclude alternative explanations.

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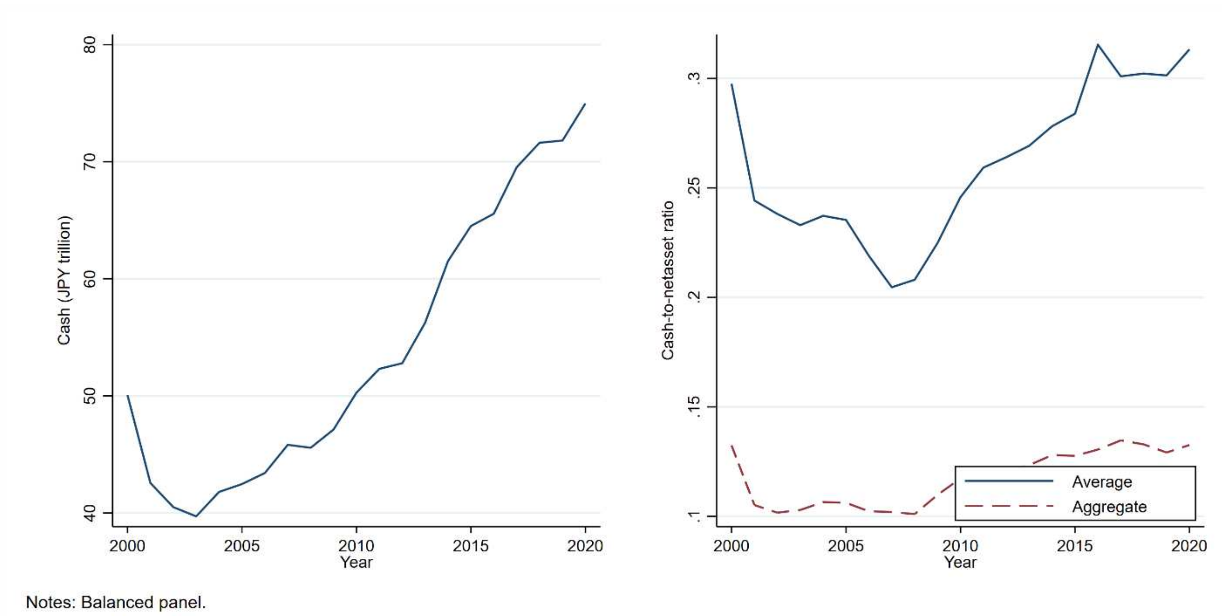
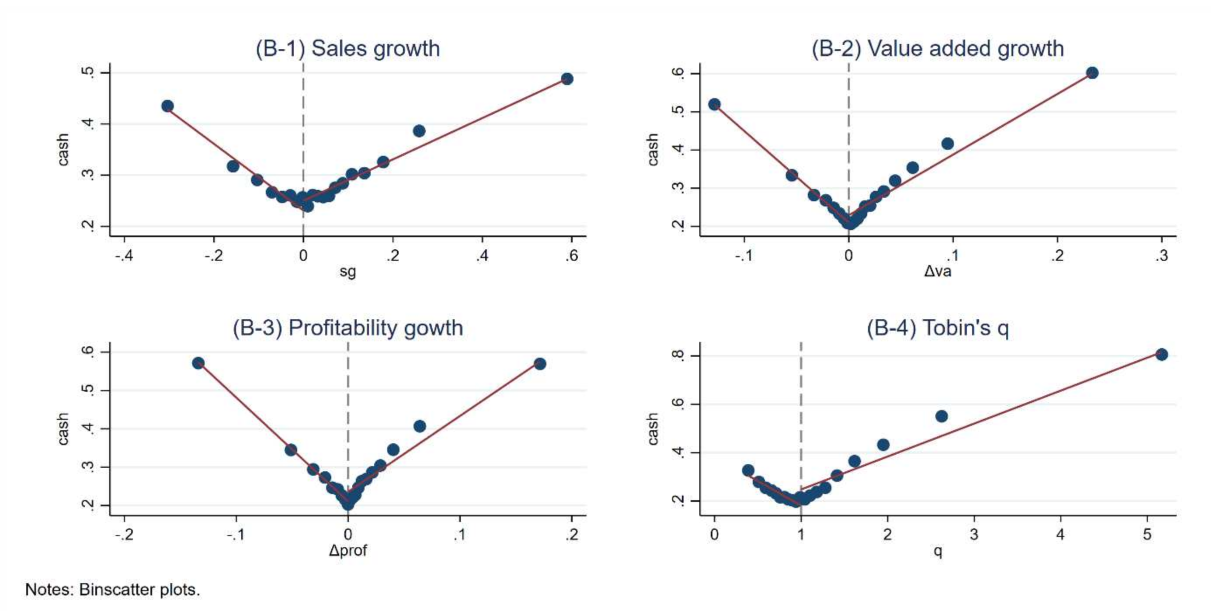
Figure 1 Stylized facts



(A) Trends of cash holdings



(B) Growth opportunity and cash holdings

Figure 2 Timing in the model

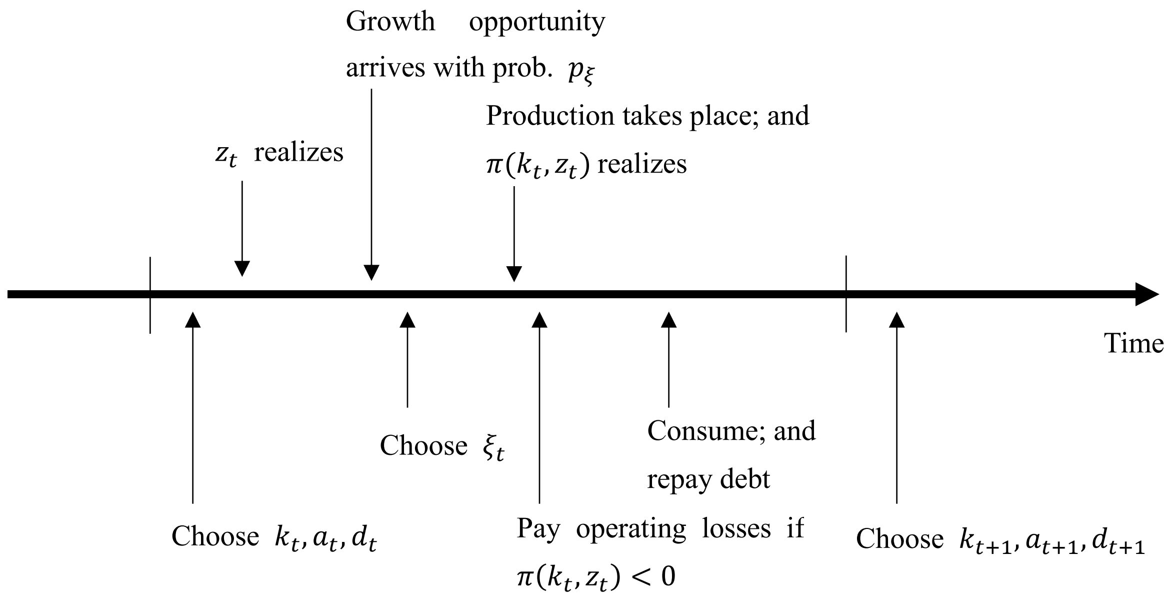
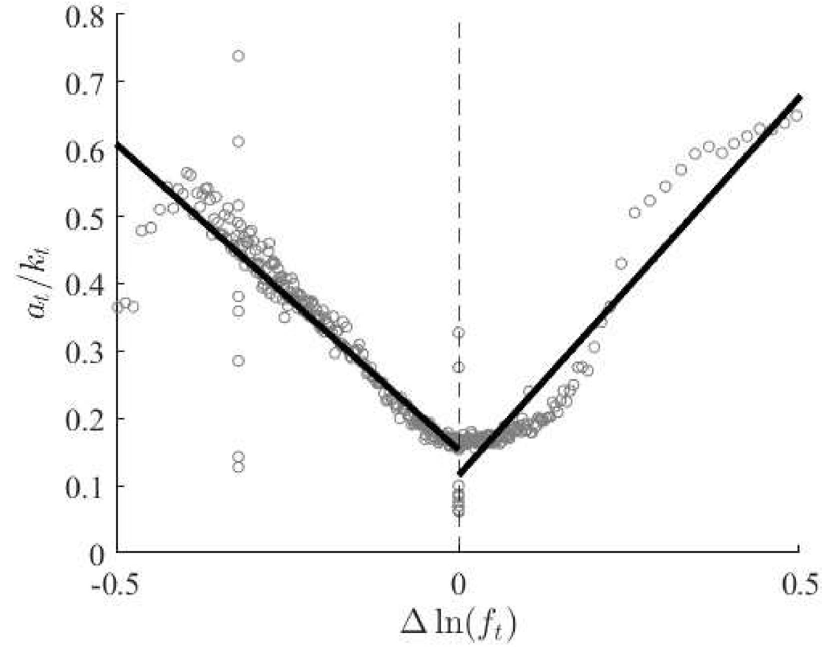
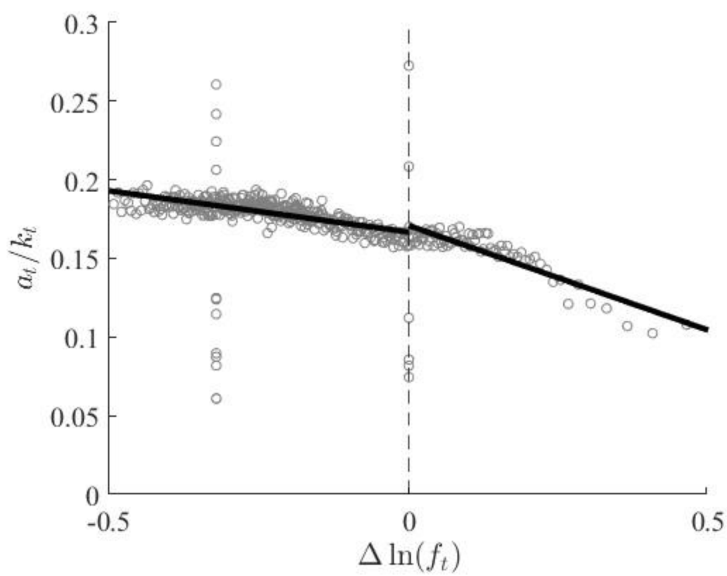


Figure 3 Cash holdings and output growth in the model

The figures show bin-scatter plots of the output growth rate (x-axis) and cash-to-capital ratio (y-axis) from a model simulation. Both series take the average from one period before to one period after. The fitted lines represent the linear relationship between the positive and negative territories of output growth rate.



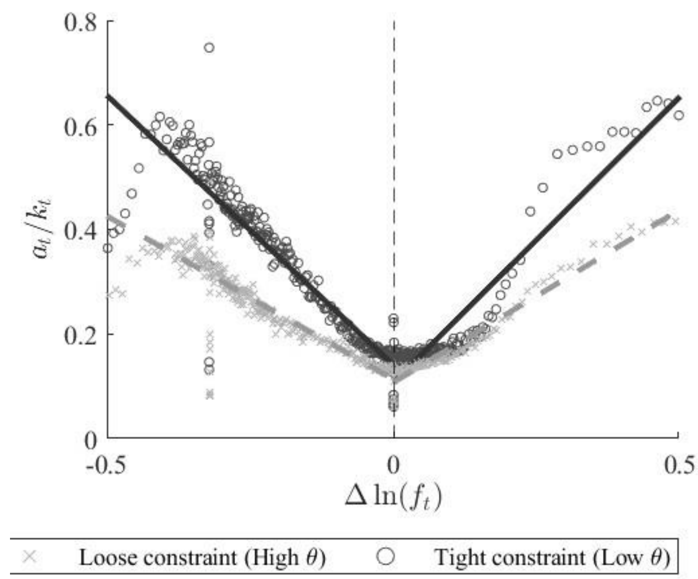
(A) Baseline



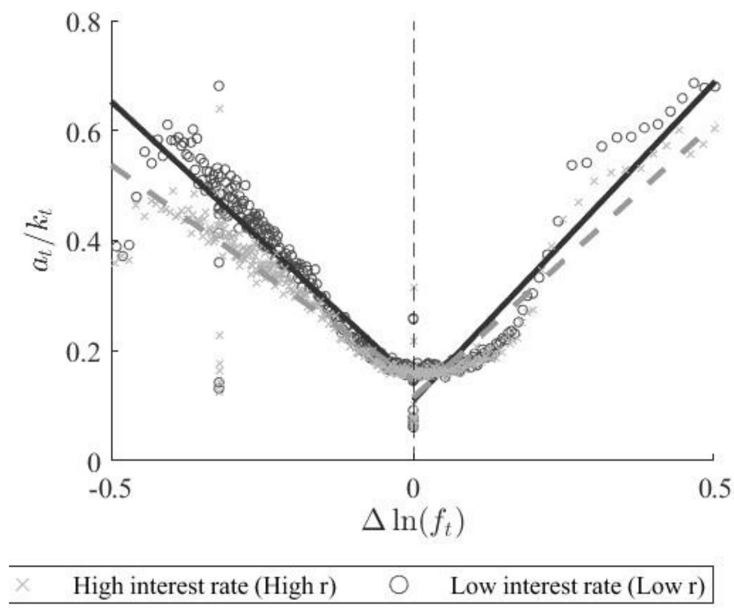
(B) Without endogenous inv. opportunity

Figure 4 Impacts of parameter values

Bin-scatter plots from the model simulation. In Panel (A), the tightness of borrowing constraint (θ) is set according to the pre-GFC period (2000-07, $\theta = 0.66$) and the post-GFC period (2010-20, $\theta = 0.52$). Similarly, in Panel (B), the borrowing interest rate (r) is calibrated to reflect the decline in the bank lending rate after the GFC (-0.8 pp). The calibrated parameters were $r = 0.037$ for the pre-GFC and r = 0.029 for the post-GFC periods, respectively.



(A) Tightness of borrowing constraint



(B) Borrowing interest rate

Figure 5 Agency Conflicts

Bin-scatter plots from a model simulation. “No Agency Cost” is the baseline case where there are no agency conflicts. “Nikolov-Whited” embeds agency conflicts with Nikolov and Whited (2014)’s estimated parameters of $s_1 \times 1000 = 0.101$ and $s_2 = 0.051$. “Lower s_2” is a case where s_2 is reduced to 0.051/20.

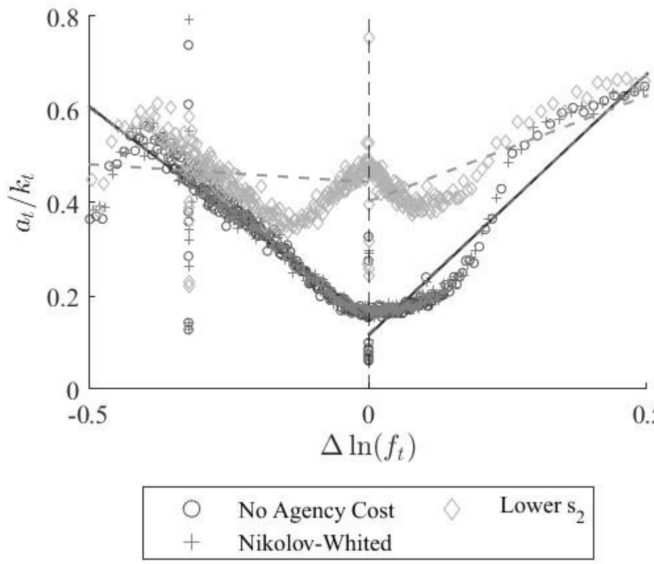


Table 1 Descriptive statistics

	mean	sd	1st quantile	median	3rd quantile
cash	0.2987	0.3727	0.0929	0.1797	0.3431
$cash^{only}$	0.2739	0.3437	0.0851	0.1642	0.3130
sg	0.0433	0.1803	-0.0378	0.0265	0.0975
Δva	0.0145	0.0707	-0.0115	0.0065	0.0295
Δprof	0.0054	0.0581	-0.0115	0.0029	0.0186
1(*sg* < 0)	0.3809	0.4856	0	0	1
1(*Δva* < 0)	0.3904	0.4878	0	0	1
1(*Δprof* < 0)	0.4259	0.4945	0	0	1
size	10.5336	1.6788	9.3751	10.4023	11.5216
cf	0.0478	0.0714	0.0189	0.0529	0.0860
lev	0.4899	0.2129	0.3229	0.4891	0.6511
nwc	0.1902	0.1335	0.0925	0.1686	0.2568
capex	0.0364	0.0370	0.0103	0.0260	0.0505
rd	0.0143	0.0222	0	0.0047	0.0194
acq	0.0027	0.0110	0	0	0
1(*div* > *0*)	0.8399	0.3667	1	1	1

Table 2 Regression analysis

	cash						
growth = ?	Sales Growth					Value Added	Profitability
	Subsample		Entire sample				
	sg < 0	*sg* > 0					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Growth	**-0.1250*** **	**0.0331** **	**0.3089*** **	**0.2328*** **	**0.0305** **	**0.1061*** **	**0.1599*** **
	(0.0257)	**(0.0137)**	**(0.0189)**	**(0.0188)**	**(0.0132)**	**(0.0392)**	**(0.0597)**
1(*growth* < 0)			-0.1422***	-0.0988***	0.0329*	0.0481***	-0.0076
			(0.0353)	(0.0323)	(0.0182)	(0.0172)	(0.0159)
***growth* × 1(*growth* < 0)**			**-0.7042*** **	**-0.5973*** **	**-0.1658*** **	**-0.4492*** **	**-0.4755*** **
			(0.0483)	**(0.0483)**	**(0.0283)**	**(0.0777)**	**(0.1063)**
Observations	20,047	32,636	52,683	52,683	52,683	52,683	52,683
Control	yes	yes	yes	yes	yes	yes	yes
control × 1(*growth* < 0)	no	no	yes	yes	yes	yes	yes
Year	yes	yes	no	yes	yes	yes	yes
Industry	no	no	no	yes	no	no	no
Firm	yes	yes	no	no	yes	yes	yes
clustered by	firm	firm	firm	firm	firm	firm	firm
Adj. R^2	0.809	0.800	0.372	0.448	0.792	0.792	0.792

This table shows the results of regression models estimation the correlation between corporate cash holdings and corporate growth. Standard errors clustered by firm are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 3 Regression analysis: Robustness test

	$cash^{only}$						
growth = ?	Sales Growth					Value Added	Profitability
	Subsample		Entire Sample				
	sg < 0	*sg* > 0					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Growth	**-0.1014*** **	**0.0296** **	**0.2984*** **	**0.2304*** **	**0.0301** **	**0.1023*** **	**0.1539*** **
	(0.0233)	**(0.0127)**	**(0.0174)**	**(0.0170)**	**(0.0124)**	**(0.0368)**	**(0.0506)**
1(*growth* < 0)			-0.1330***	-0.0941***	0.0230	0.0337**	-0.0154
			(0.0321)	(0.0290)	(0.0159)	(0.0157)	(0.0145)
***growth* × 1(*growth* < 0)**			**-0.6732*** **	**-0.5739*** **	**-0.1431*** **	**-0.3856*** **	**-0.4236*** **
			(0.0429)	**(0.0429)**	**(0.0259)**	**(0.0715)**	**(0.0922)**
Observations	20,047	32,636	52,683	52,683	52,683	52,683	52,683
Control	yes	yes	yes	yes	yes	yes	yes
control × 1(*growth* < 0)	no	no	yes	yes	yes	yes	yes
Year	yes	yes	no	yes	yes	yes	yes
Industry	no	no	no	yes	no	no	no
Firm	yes	yes	no	no	yes	yes	yes
clustered by	firm	firm	firm	firm	firm	firm	firm
Adj. R^2	0.815	0.810	0.385	0.465	0.803	0.803	0.803

Standard errors clustered by firms are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 4 Calibrated parameters

Symbol	Description	Value	Source
β	Subjective discount rate	0.9680	SNA, capital-to-output ratio=2.188
χ	Exit rate	0.0185	FQ, average firm age=54
r	Interest rate for borrowing	0.0525	Euler equation
α	Capital share	0.407	SNA, capital share=40.7%
η	Profit share	0.036	SNA, dividend share=3.6%
τ	Profit tax rate	0.30	MoF, effective tax rate=30%
δ	Depreciation rate	0.111	SNA, depreciation rate=11.1%
w	Wage rate	1.0	Normalization
θ	Borrowing constraint	0.54	FQ, 5th percentile of NFA/net asset =0.54
μ	Investment adjustment cost	0.5	Nikolov and Whited (2014)
σ	S.D. of stationary productivity shocks	0.05	FQ, s.d. of sales growth=0.18
ϕ_1	Parameter of productivity process	0	No deterministic growth
ϕ_2	Parameter of productivity process	0.02	FQ, average cash/net asset=30.0%
p_ξ	Prob. of investment opportunity	0.35	FQ, average sales growth=4.3%
γ	Catastrophic shock	-0.45	FQ, 5th percentile of operating profit/net asset=-4.8%
p_γ	Prob. of catastrophic shock	0.05	A shock once in 20 years

Table 5 Drivers of increase in liquidity holdings

	Change in average cash holdings
Data (from pre-GFC to post-GFC)	+10.3 pp
Baseline Model	
Tightening of borrowing constraint (θ = 0.66 → 0.52)	+4.7 pp
Lower interest rate (*r* = 0.037 → 0.029)	+1.9 pp
Model without inv. opportunity	
Tightening of borrowing constraint (θ = 0.66 → 0.52)	+0.5 pp
Lower interest rate (*r* = 0.037 → 0.029)	+0.2 pp

The data row reports the change in the average NFA-to-capital ratio from the pre-GFC period (2000-07) to the post-GFC period (2010-20). The model rows report the differences in the cash-to-capital ratio (a_t/k_t) across different parameter values. The calibration of each parameter is shown in Fig. 4.

Appendix on

"Passive and proactive motivations of cash holdings"

Table A1 Variable definitions

Variables	Definition
cash	Sum of cash and short-term security scaled by total assets minus sum of cash and short-term security.
$cash^{only}$	Cash scaled total assets minus sum of cash and short-term security.
sg	Change in sales from the previous period scaled by lagged sales.
Δva	Change in gross profit from the previous period scaled by total assets.
Δprof	Change in operating income from the previous period scaled by total assets.
q	Sum of market cap of equity and debt scaled by total assets.
$1(growth < 0)$	Dummy variable taking one if the firm experiences negative growth.
size	Natural logarithm of lagged total assets.
cf	Operating cash frow scaled by total assets.
lev	Sum of short- and long-term interest-bearing debt scaled by total assets.
nwc	Current assets minus cash less non-interest-bearing current liabilities scaled by total assets.
capex	Capital expenditure scaled by total assets.
rd	R&D expenditure scaled by total assets.
acq	M&A expenditure scaled by total assets.
$1(div > 0)$	Dummy variable taking one if the firm pay dividends.