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Corporate Liquidity Management: A Conceptual Framework and Survey

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Abstract

Ensuring that a firm has sufficient liquidity to finance valuable projects that occur in the future is at the heart of the practice of financial management. However, although discussion of these issues goes back at least to Keynes (1936), a substantial literature on the ways in which firms manage liquidity has developed only recently. We argue that many of the key issues in liquidity management can be understood through the lens of a framework in which firms face financial constraints and wish to ensure efficient investment in the future. We present such a model and use it to survey many of the empirical findings on liquidity management. In addition, we discuss agency-based theories of liquidity, the real effects of liquidity choices, and the impact of the 2008–2009 Financial Crisis on firms' liquidity management.

1. INTRODUCTION

The 2008–2009 Financial Crisis has renewed interest in the way in which firms manage liquidity, given firms' access to external financing was a major determinant of firms' survival during this period. However, liquidity management is an old topic and has been discussed at least since Keynes' (1936) *General Theory of Employment, Interest and Money*. Keynes argued that liquidity management and financing constraints are fundamentally linked: If financial markets work as well as we typically assume they do, firms' liquidity decisions would be irrelevant. As with most corporate financial decisions, it is only to the extent that financial markets contain frictions that liquidity decisions are interesting.

Many CFOs consider decisions about corporate liquidity to be among the most important decisions they make; to a large extent, they view their job as finding a way to fund investments proposed by the CEO (see, e.g., Graham & Harvey 2001). The way in which firms manage liquidity is clearly an important concern to practitioners and policy makers, and has become an active area of research. Liquidity management contains several issues for CFOs to address, but the main ones come down to the question of how liquid the firm's position ought to be and how to maintain this given level of liquidity (through cash, lines of credit, hedging, or other mechanisms).

The literature on optimal cash holdings took off around 2000, motivated by the growing cash balances held by US firms at that time.[1] This literature has led our understanding of the unique role that cash holdings play in firms' liquidity management to grow substantially. Early models of optimal cash holdings ignore other mechanisms to manage liquidity and focus on the precautionary motive for holding cash. Since then, the literature has considered the role of cash holdings when other options such as debt capacity, derivatives, and credit lines are also available. The broad conclusion of this literature is that cash remains king, at least for certain groups of firms. Debt capacity does not provide the same degree of downside protection as cash holdings and derivatives can only help with a limited set of risks that are traded in the market. Although bank credit lines are the best all-around substitute for cash holdings, firms with large liquidity risks still tend to prefer cash, especially if their liquidity risk is aggregate in nature. Recent research on liquidity management has addressed these issues, as well as several others, including the relationship between firms' decisions about liquidity and the financial constraints they currently face or are likely to face in the future, and the extent to which taxes and agency considerations affect firms' liquidity decisions.

This article surveys the literature on liquidity management. It does so through the lens of a model in which firms hold liquidity to ensure efficient investment in the future while simultaneously attempting to motivate management to provide a high effort level. Keynes' notion of a precautionary motive for having a liquid balance sheet presumes that in some states of the world, firms are financially constrained; such constraints occur endogenously in the model because of a limited pledgeability problem that arises from moral hazard. It turns out that many insights about liquidity management can be understood through this framework.[2]

Because cash holdings are the most common way for firms to ensure liquidity, the literature has paid much attention to the determinants of cash holdings. Cash holdings vary both across

[1]Meltzer (1963), Miller & Orr (1966), and Baumol (1970) provide an earlier literature that focuses on the transaction motive to hold cash using inventory-type models of cash holdings.

[2]The insight that firms manage liquidity because of financing constraints was first brought to the forefront of corporate finance research by Froot, Scharfstein & Stein (1993). However, our model follows Holmstrom & Tirole (1998) and Tirole (2006) for convenience. Although their moral hazard framework is a convenient modeling tool, moral hazard is not the only friction that can generate limited pledgeability and a precautionary demand for liquidity. For example, limited pledgeability also arises from an asymmetric information framework (see Tirole 2006, chapter 6).

countries and across firms within countries, and also over time. We discuss in detail several studies examining both the cross-sectional and time series behavior of the level of cash. The underlying cause of cross-sectional variation in liquidity appears to be, as Keynes suggested, variation in financial frictions that these firms expect to experience in the future. However, it remains a puzzle why the level of cash held by most firms has varied so much, and in particular, why cash holdings have increased so dramatically in recent years.

In addition to the level of cash holdings, theory predicts that the sensitivity of cash holdings to cash flows should depend on whether the firm is financially constrained. We explain in detail why corporate savings in response to incremental cash flows are likely to be related to the financial frictions firms face. Overall, the evidence suggests that, consistent with theory, a firm's cash flow sensitivity of cash tends to be positive for financially constrained firms and close to zero for unconstrained firms.

The cash flow sensitivity of cash is likely to be a useful measure of financial constraints, because of its theoretical and empirical relations with the existence of financial constraints. It reflects the management's own view on the likelihood of facing financial constraints in the future, which is useful in many applications. Several papers have used this approach to answer various questions, and it appears to be useful at identifying constrained and unconstrained firms.

Although there are theoretical reasons to focus on cash when studying liquidity management, this focus is not always appropriate. The literature's focus on cash has been partially driven by the lack of data on substitute mechanisms such as credit lines and derivatives-based hedging. However, it is increasingly feasible to incorporate these alternative mechanisms into empirical studies. For example, recent studies have documented that the existence of undrawn credit lines can add substantially to a firm's liquidity. Firms that hold undrawn credit lines also hold some cash, but firms without access to credit lines hold significantly more cash than the average firm.

Crucially, corporate liquidity management may have implications for firms' real activities such as investment, employment, research and development (R&D), and mergers. Understanding the way in which liquidity management can alleviate the impact of financing frictions on real activity is of interest not only for researchers, but also for policy makers. In that vein, corporate liquidity has been examined in conjunction with issues such as collective bargaining and unionized labor, product market competition, investment in R&D, and mergers and acquisitions (M&As). Our article describes connections between liquidity management and real corporate activity as well, including the role cash played in the 2008–2009 Financial Crisis.

Naturally, our article cannot cover the entire spectrum of research on corporate liquidity. To keep our review manageable, we remain silent on literatures focusing on issues such as estimates of the value of cash (Faulkender & Wang 2006, Pinkowitz & Williamson 2007), the asset pricing implications of corporate liquidity (Acharya, Davydenko & Strebulaev 2012; Palazzo 2012), and dynamic models of cash (Riddick & Whited 2009; Bolton, Chen & Wang 2011). Dynamic models of liquidity and other corporate policies are discussed in Strebulaev & Whited (2012), who review the structural approach to several issues in corporate finance.

2. HOW MUCH LIQUIDITY TO HOLD: THEORY AND EVIDENCE

We present a model of liquidity management based on Holmstrom & Tirole (1998) and Tirole (2006). The model is meant to provide a unifying framework that helps to understand many of the key results in the liquidity management literature. In it, firms' demand for liquidity arises because of a moral hazard problem that prevents firms from pledging all of their cash flows to outside investors. This framework provides insights into the underlying reasons for holding cash, the

factors that affect the cross-sectional and time-series patterns in cash holdings, and the value of holding cash relative to other sources of liquidity, such as lines of credit, debt capacity, or the use of derivatives to hedge.

2.1. Model Assumptions

Consider a firm with an investment project that requires I at date 0. The firm's initial net worth is $A > 0$. The investment opportunity also requires an additional investment at date 1. The date-1 investment requirement can equal either ρI, with probability λ, or zero, with probability $(1 - \lambda)$.[3] There is no discounting and everyone is risk neutral.

Figure 1 depicts the timeline of the investment and financing game. A firm will only continue its date-0 investment until date 2 if it can meet its date-1 liquidity need. If the liquidity need is not met, the firm is liquidated and the project produces a cash flow equal to zero. If the firm continues, the investment produces a date-2 cash flow R per unit of investment that occurs with probability p. With probability $1 - p$, the investment produces nothing. The probability of success depends on the input of specific human capital by the firms' managers. If the managers exert high effort, the probability of success is equal to p_G. Otherwise, the probability is p_B, but the managers consume a private benefit equal to B. This moral hazard problem implies that the firms' cash flows cannot be pledged in their entirety to outside investors. Following Holmstrom & Tirole (1998), we define

$$\rho_0 \equiv p_G \left(R - \frac{B}{p_G - p_B} \right) < \rho_1 \equiv p_G R. \tag{1}$$

The parameter ρ_0 represents the investment's pledgeable income per unit of investment and ρ_1 its total expected payoff per unit. The model's main friction is this wedge between the total expected payoff and the pledgeable income. The other key assumption of the model is that

$$\rho_0 < \rho < \rho_1. \tag{2}$$

This assumption implies that it is efficient to continue the project in state λ but that pledgeable income per unit is lower than the required investment. In addition, we make the following assumptions:

$$\rho_1 - \lambda\rho - 1 > 0 > \rho_0 - \lambda\rho - 1 \tag{3}$$

and

$$(1 - \lambda)\rho < 1. \tag{4}$$

Equation 3 implies that the project's net present value (NPV) is positive and that the feasible investment level is finite.

Equation 4 is necessary and sufficient to ensure that the firm finds it optimal to continue the project in state λ. In other words, the firm finds it optimal to withstand the liquidity shock if it is small and likely to happen. If this condition does not hold, then liquidity management becomes irrelevant for the firm.

[3]One interpretation for this setup is that state λ is a state in which the firm produces low short-term cash flows, which are insufficient to cover date-1 investment requirements.

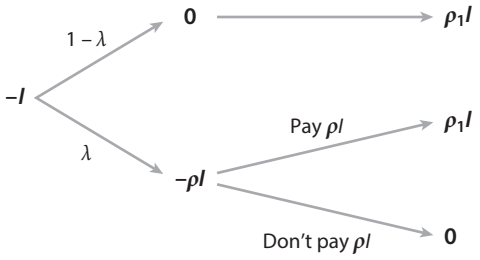


Figure 1

Model timeline.

The firm's date-0 budget constraint is

$$I \leq A + (1-\lambda)\rho_0 I + \lambda(\rho_0 - \rho)I. \tag{5}$$

Because $\rho_1 - \lambda\rho - 1 > 0$, it is optimal to invest as much as possible, and thus the budget constraint will bind. The firm's optimal investment level is given by

$$I^* = \frac{A}{1-\rho_0+\lambda\rho}, \tag{6}$$

and the associated firm's payoff is given by

$$U^* = (\rho_1 - \lambda\rho - 1)I^*. \tag{7}$$

2.2. Value from Liquidity Management

Corporate demand for liquidity arises from the assumption that $\rho_0 < \rho$. The total amount of external finance that the firm can raise at date 1 is given by $\rho_0 I$,[4] but the required investment is ρI. This means that the firm must bring liquidity from date 0 to be able to finance efficient continuation at date 1. Denote the quantity of liquidity demanded by the firm by L. The demand for liquidity associated with the investment level I^* is

$$L^* = (\rho - \rho_0)I^*. \tag{8}$$

At the initial date (date 0), the firm must raise external finance to fund the investment level I^* and secure liquidity equal to L^*. For example, the firm can borrow more than what is strictly necessary to fund the investment level I^* and hold the balance $(\rho - \rho_0)I^*$ as cash reserves. Assuming that the cash balances held by the firm are fully pledgeable to outside investors, date-0 investors' break-even constraint is[5]

$$(1+\rho-\rho_0)I^* - A = (1-\lambda)\left[\rho_0 I^* + (\rho-\rho_0)I^*\right], \tag{9}$$

which is equivalent to the expression for I^* derived above.

[4]This expression assumes that the firm can issue senior claims at date 1. If the date-0 claims are senior, then the firm will need to hold more liquidity to withstand the liquidity shock. All conclusions that we derive below are independent of assumptions about seniority.

[5]This constraint assumes that the liquidity held until date 1 is returned to investors in state $1-\lambda$ with no waste. Waste of cash balances introduces additional considerations discussed below.

2.3. Optimal Cash Holdings

Keynes' (1936) arguments as well as the relatively early empirical papers focus on cash holdings as firms' only option to manage liquidity. If we denote cash holdings by C^* in this model, $L^* = C^*$. Optimal cash holdings are given by

$$C^* = (\rho - \rho_0)I^* = \frac{(\rho - \rho_0)A}{1 - \rho_0 + \lambda\rho}. \tag{10}$$

This expression conveys the two main implications of Keynes' argument: First, cash holdings have value because they enable the firm to undertake investment opportunities; as such cash holdings increase with the firm's investment (I^*). Second, the importance of cash to a firm depends on the likelihood that the firm will face a liquidity shortfall and have to use the cash to finance investments. In the context of the model, the implication is that controlling for the level of investment I^*, optimal cash holdings also increase with the size of the liquidity shortfall $(\rho - \rho_0)$.

2.4. Empirical Work on the Quantity of Cash Firms Hold

Probably the most well-known paper on the optimal level of cash holdings is Opler et al. (1999). This paper examines the implications of Equation 10, which characterizes the way in which firms have a target level of cash that increases with firms' growth opportunities and with the riskiness of firms' cash flows. Using a sample of large, publicly-traded US firms, Opler et al. find that firms with more growth opportunities and riskier cash flows have higher cash-to-assets ratios, whereas firms that are likely to have better access to capital markets have lower cash-to-assets ratios. These findings are consistent with Keynes' arguments formalized in the model presented above.

The evidence in Opler et al. (1999) establishes fairly persuasively that firms have a target level of cash and that this target varies depending on the value of the firm's investments and the likelihood that the firm will not be able to finance these investments absent retained cash. What is more difficult to establish is that this level is optimal in that it trades off the costs and benefits of holding cash. Moreover, there are substantial secular trends in firms' cash levels. **Figure 2** below shows that among the restricted group of nonfinancial S&P500 firms, cash holdings jumped from $200 billion in 1996 to $1,334 billion in 2012. In addition to the large quantity of cash firms hold, they are also becoming more liquid, with the median cash-to-assets ratios at all-time highs in recent years.

There are several possible explanations for this secular increase in cash holdings. First, if the costs of holding cash decreased or the benefits increased, a model such as the one presented above would imply that cash holdings should increase. For example, a secular increase in cash flow risk could explain the increase in cash holdings. Alternatively, the increase in cash could reflect the changing composition of firms over the sample period. Bates, Kahle & Stulz (2009) consider these explanations and find evidence consistent with the compositional explanations. In particular, since the 1990s, for a typical cash flow, volatility has increased, capital expenditures have decreased, and research and development have increased, all of which tend to be associated with higher cash holdings. Bates, Kahle & Stulz (2009) conclude that these factors could have led to a large increase in the quantity of cash holdings. Still, the literature has not been able to explain the sources of this increase in cash holdings completely.

An important issue in measuring cash is that many US firms hold substantial quantities of cash in other countries and face substantial repatriation taxes should they return their cash to the United States. For example, Apple Computer currently holds a particularly large quantity overseas ($82.6 billion), so that the total quantity of cash they hold dramatically overstates the amount of cash they have available to spend. For this reason, despite their extremely high cash balance, Apple in April

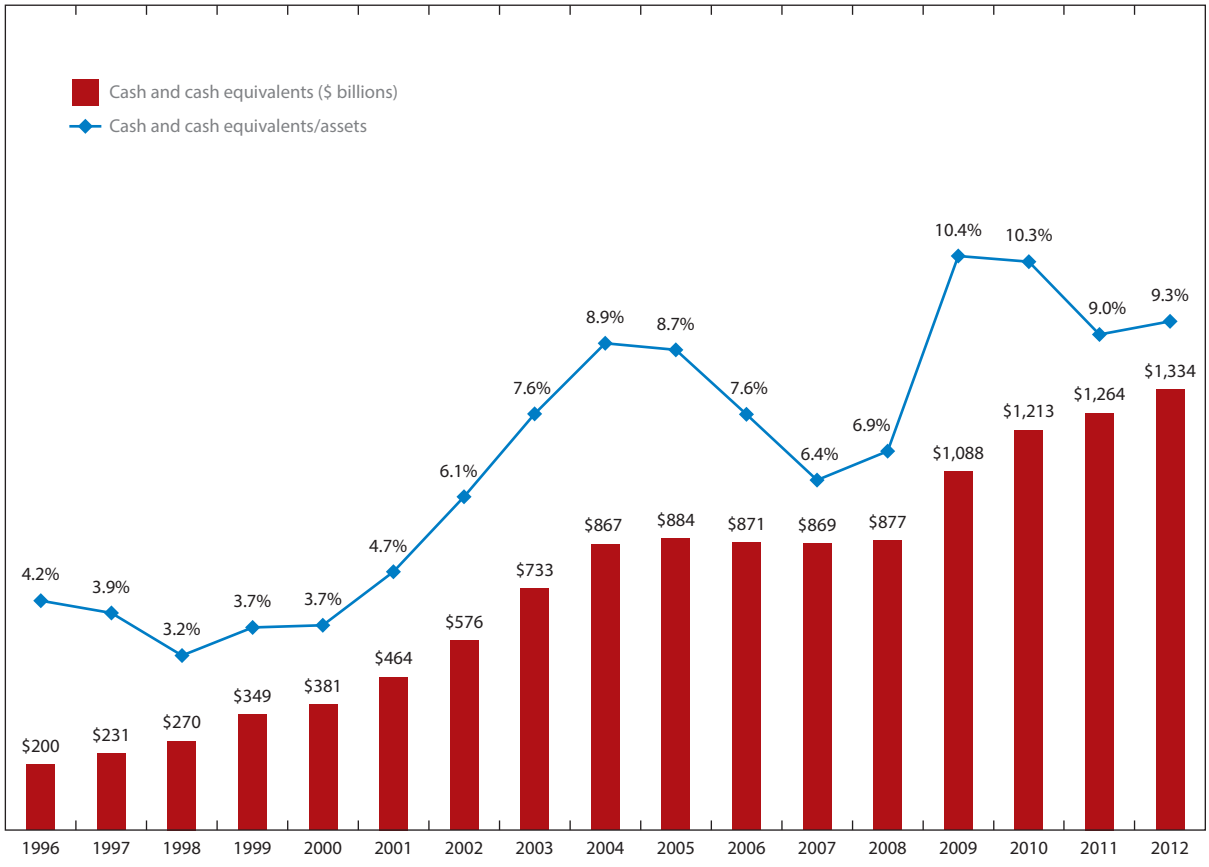


Figure 2

Historical cash balances of large corporations.

2013 issued the largest corporate bond offering in history ($17 billion) as part of a plan to return money to shareholders; repatriation taxes precluded their using overseas cash for this purpose.

Foley et al. (2007) consider the extent to which repatriation taxes explain the quantity of cash that firms hold. These authors document several empirical findings consistent with the view that Apple is not unique, and that repatriation taxes are an important factor determining multinationals' cash holdings. In particular, Foley et al. (2007) find that firms facing higher repatriation taxes have higher cash holdings and tend to hold this cash abroad, in affiliates that would trigger high tax costs when repatriating earnings. Consequently, as in the Apple case, cash levels can be misleading measures of liquidity when firms have to pay large repatriation costs to use the cash in their home country.

Pinkowitz, Stulz & Williamson (2013) consider the question of whether cash holdings have become abnormally high following the Financial Crisis of 2008–2009. These authors document that compared to a 1990s benchmark, US firms increased their cash holdings significantly more than foreign firms. Firms did not increase their cash holdings dramatically during the crisis. This increase occurred mainly before the financial crisis and appears to be concentrated in multinational firms. The authors present a different perspective for the cash overseas discussion. They argue that the increase in cash (although not the cross-sectional pattern) cannot be explained by

repatriation taxes, given that cash holding levels of these multinationals did not decrease after the Homeland Investment Act of 2004, even with the large repatriations reported in the literature.[6]

2.5. The Cash Flow Sensitivity of Cash

Almeida, Campello & Weisbach (2004) introduce the notion of the cash flow sensitivity of cash, which is the fraction of incremental cash flows that is retained by the firm as additional cash. In the Almeida, Campello & Weisbach model, unconstrained firms invest at the first-best level, so incremental cash flows do not have any real effects on the firm's investments. However, a firm facing financial constraints will choose to allocate additional cash flows to increase their investments both today and in the future, so cash holdings to finance future incremental investment should increase with their cash flows. Consequently, the fraction of cash retained by a firm from incremental cash flows reflects management's own view as to whether the firm is likely to face financial constraints in the future.

A similar finding occurs in the model presented here. The expression for optimal cash holdings in Equation 10 implies that cash holdings increase with A, which measures the firm's available internal funds in the model. An increase in A will increase optimal investment I but also force the firm to save more liquidity for the future so that the investment can be continued in state λ. Therefore, for constrained firms, the sensitivity of cash to changes in A is positive. In the model, we can capture the degree of financial constraints by the wedge between the required future investment and pledgeable income, $\rho - \rho_0$. As ρ_0 becomes greater than ρ, the demand for liquidity goes away and the firm no longer has a need to hold cash. The conclusion is that the implications above about the levels and the cash flow sensitivity of cash holdings should hold only if the firm is financially constrained.[7]

Almeida, Campello & Weisbach (2004) perform several tests of the hypothesis that a positive cash flow sensitivity of cash corresponds to the existence of financial constraints. These authors consider a sample of US companies and classify them as constrained or unconstrained using five measures of constraints that have been historically used in the literature; the measures are constructed based on dividend payouts, asset size, the existence of a bond rating, the existence of a commercial paper rating, and the KZ index, which is based on an econometric model using the classification of firms in Kaplan & Zingales (1997). For all of the constraints measures except the KZ index (which turns out to be negatively correlated with the other measures of constraints), the estimated cash flow sensitivity of cash is positive for the constrained subsample and close to zero and statistically insignificant for the unconstrained subsample. This pattern is consistent with the intuition of the Almeida, Campello & Weisbach (2004) model in which a positive cash flow sensitivity of cash is associated with financial constraints.[8]

The cash flow sensitivity of cash has been used to measure financial constraints in a number of different contexts. In each case, the cash flow sensitivity of cash provides a measure of financial

[6]Dharmapala, Foley & Forbes (2011) show how the Homeland Investment Act of 2004 allowed for the repatriation of some $300 billion at extraordinarily low tax levels. They report that firms used the cash to pay back investors instead of investing in the business and increasing employment as the law intended.

[7]Riddick & Whited (2009) study a dynamic model of cash holdings in which shocks to cash flow contain information about future cash flow. Their main idea can be embedded in our framework. If A is positively correlated with future cash flows, for example, then an increase in A also reduces the size of the shortfall $\rho - \rho_0$ and thus the need to save liquidity in the first place. In this case, cash flow sensitivities of cash could also be negative.

[8]The patterns described in Almeida, Campello & Weisbach (2004) have been confirmed in a number of papers, using data from both US and foreign firms (e.g., Khurana, Martin & Pereira 2006). Riddick & Whited (2009) also replicate the same findings; however, the results they find using alternative, "high-order" estimators are noticeably different.

constraints that leads to an inference of constraints in circumstances in which firms are a priori likely to be constrained and also in which other measures of constraints indicate they are present. For example, Sufi (2009) finds that being constrained, measured by the lack of a credit line, is associated with a positive cash flow sensitivity of cash. Hadlock & Pierce (2010) use the cash flow sensitivity of cash to corroborate the classification of firms based on the size-age index of constraints introduced in that paper. Finally, Erel, Jang & Weisbach (2014) use the cash flow sensitivity of cash to evaluate whether small, European merger targets were constrained prior to being acquired, and whether the constraints are relieved by the acquisition. (Other such examples are Yun 2009; Farre-Mensa 2011; Ostergaard, Sasson & Sorensen 2010.)

2.6. Cash versus Debt Capacity

The model can also be used to understand the key difference between cash and debt capacity (or negative debt) that is identified by Acharya, Almeida & Campello (2007). Can the firm save liquidity by borrowing less at date 0 and holding debt capacity for date 1? To give a concrete example, suppose that the firm decides to borrow nothing at date 0 and thus make $I = A$. This investment level creates pledgeable income $\rho_0 A$ if continued until date 2, and the firm must pay an additional ρA on date 1 if it is hit with a liquidity shock. The key point to note is that this strategy does not provide the firm with sufficient liquidity in state λ, because $\rho > \rho_0$. Even though the firm has no debt, the maximum amount that it can borrow at date 1 is constrained by total pledgeable income $\rho_0 A$, which is lower than the required investment in state λ, ρA.[9] The low debt strategy does create excess debt capacity (equal to $\rho_0 A$) but only in state $1 - \lambda$, where it is not needed. The optimal financial policy in this context is to transfer financing capacity from state $1 - \lambda$ (where it is plentiful and less valuable) to state λ (where it is scarce and valuable). This goal can be accomplished by increasing the amount of date-0 borrowing and using the excess liquidity in state $1 - \lambda$ to make (long-term) debt payments. (We can think of this type of debt taking as precautionary borrowing.) Cash savings thus allow the firm to transfer financing capacity from good to bad states of the world.[10]

3. ALTERNATIVE FORMS OF LIQUIDITY

In the example above, cash creates financial flexibility because it gives the firm access to committed liquidity. Other forms of financing that rely on spot contracting such as equity issuance and commercial paper borrowing share the same problem as debt capacity—access to such financing may not be there when the firm needs it the most. However, cash is not the only way in which the firm can access precommitted financing. Hedging and lines of credit also serve to provide firms with liquidity in states of the world in which it is potentially valuable. We now discuss the literature describing the way in which hedging and lines of credit are used as part of the liquidity management process.

[9]The firm may be able to withstand the liquidity shock by investing less than A at date 0, but this requires holding the balance $I - A$ as cash. Thus, such a firm would be relying on cash and not on debt capacity for liquidity management. In addition, such a solution is dominated by the solution above (I^*), which allows the firm to invest more than A by issuing additional external financing and holding cash.

[10]Acharya, Almeida & Campello (2007) also analyze a more general case in which the firm has date-1 investments in both high and low liquidity states. They show that cash transfers investment capacity from high to low liquidity states, whereas debt capacity has the opposite effect. Thus, firms that value liquidity in high liquidity states may prefer debt capacity if there are (deadweight) costs of holding cash.

3.1. Hedging Through Derivatives

In the solution previously discussed, the firm transfers funding capacity from good to bad states of the world by holding cash. The bad state of the world (state λ) is defined by the arrival of the liquidity shock ρ. Clearly, any asset that makes payments to the firm in state λ will perform a similar role. To see why, suppose that the firm has access to a derivative that makes state contingent payments by y_λ and $y_{1-\lambda}$. These payments satisfy

$$\lambda y_\lambda + (1-\lambda) y_{1-\lambda} = 0. \tag{11}$$

This condition means that the firm's counterparty can offer the derivative at an actuarially fair price. If the firm can buy an unlimited amount of exposure to the derivative, for a given investment I it can set $y_\lambda = (\rho - \rho_0)I$, and thus $y_{1-\lambda} = -\lambda I \dfrac{\rho - \rho_0}{1-\lambda}$. Such a derivative position eliminates the firm's liquidity risk and allows the firm to finance the same level of investment as above (I^*), without holding cash. Thus, derivatives can perfectly substitute for cash holdings, because they transfer cash flows to those states of the world where they are needed (Froot, Scharfstein & Stein 1993). (A related argument was originally made by Smith & Stulz 1985, who show that hedging can reduce the costs of financial distress and thereby increase the firm's debt capacity.)

Campello et al. (2011b) empirically consider the way in which hedging affects investment. Similar to the logic originally proposed by Froot, Scharfstein & Stein (1993), Campello et al. (2011b) argue that when firms hedge with derivatives, they can commit to a lower cost of financial distress and enhance their abilities to invest. Consistent with this idea, Campello et al. (2011b) document that firms that hedge face lower loan spreads, and the terms of their debt contracts place fewer covenants on the investment decisions.

An important limitation of derivatives is that they can only allow firms to hedge certain types of risks. Firms that are significantly exposed to traded sources of risk such as foreign currency and commodity price risk are potentially able to employ derivatives-based hedging (Disatnik, Duchin & Schmidt 2013). In contrast, if the liquidity shortfall is due to firm-specific factors, the firm might not be able to fully hedge the risk using derivatives, or they may find it optimal not to do so. Perfect hedging of firm-specific risks can lead to substantial moral hazard problems by eliminating managers' incentives to create good performance. One can introduce these considerations in the model above by assuming that there is a maximum quantity of derivatives-based hedging that is available to the firm ($y_\lambda \leq y_\lambda^{\max}$). Alternatively, one can simply assume that the liquidity need ρI is already net of any derivatives-induced risk reduction (as we do below).

In addition, as shown by Rampini & Viswanathan (2010) and Rampini, Sufi & Viswanathan (2013), hedging can be imperfect because of net worth effects engendered by collateral constraints [see Stulz & Johnson (1985)].[11] The authors use this result to explain the empirical observation that derivatives-based hedging is positively correlated with proxies for firm net worth. We derive this result in the context of our model in the appendix. This analysis suggests that their result should extend to all types of liquidity management mechanisms, including cash and bank credit

[11] Our model does not capture this possibility, because of the assumption of constant returns to scale. In the model, it is optimal for the firm to save liquidity if and only if Equation 4 holds. Firms with higher λ (liquidity shock more likely) and lower ρ (smaller liquidity shock) are more likely to hold liquidity, but initial wealth A is irrelevant. In contrast, in a model with decreasing returns, low net worth firms could find it optimal to eliminate liquidity management completely. The intuition for this result (which we show in the appendix) is as follows: To save liquidity, the firm must economize on date-0 investment. With decreasing returns, the reduction in the scale of investment becomes more costly as net worth and investment decrease because the marginal productivity of investment increases. Thus, low net worth firms are more likely not to use liquidity management.

lines. If low net worth firms use fewer derivatives because of net worth effects, then they should also hold less cash and hold less liquidity in the form of bank credit lines.

3.2. Bank Credit Lines

Bank credit lines can be structured in a way to replicate the derivative analyzed in the previous section. The key feature of a credit line is that it allows the firm to access precommitted financing up to a certain quantity in exchange for the payment of a commitment fee. Thus, similarly to derivatives, a credit line can provide liquidity insurance to firms. Boot, Thakor & Udell (1987) are among the first to formalize this idea. These authors present a model based on asymmetric information in which the firm suffers a liquidity shock. Because credit will be expensive in bad states of the world it makes sense for the firm to seek the insurance provided by a credit line. The facility works like a put option for the borrower; if the spot-market interest rates are high, the borrower can use the line and borrow at the prearranged low rate. To compensate for this expected loss, the bank charges an ex ante commitment fee.[12]

In terms of the model, we denote the size of the credit line by w and the commitment fee that the firm pays to the bank by x. In addition, the firm may need to issue external finance at date 0 to cover the difference between I and A. To keep the analysis consistent with that presented above, we assume that date-1 financing is senior to date-0 financing; however, as mentioned above, seniority is irrelevant in this simple setup. In addition, we assume that date-0 funding takes the form of debt (not a crucial assumption).

At date 0, the firm raises debt of date-0 value $D_{LC} = I - A$ in exchange for date-2 payments that are made from cash flows not used to repay date-1 obligations. For the firm to survive the liquidity shock in state λ, the credit line must obey

$$w = \rho I > \rho_0 I. \tag{12}$$

The firm has pledgeable income equal to $\rho_0 I$ in state λ, and thus Equation 12 means that the bank must agree to lend more than what the firm can repay in that state (in other words, a credit line drawdown by the firm can be a negative NPV loan to the bank). The firm compensates the bank by paying the commitment fee x in state $(1 - \lambda)$. The commitment fee is set such that the bank breaks even, given the expected loss for the bank in state λ:

$$\lambda(\rho - \rho_0)I = (1 - \lambda)x. \tag{13}$$

Notice the similarity with Equation 11, which ensures that derivatives hedging is actuarially fair. We can show that the firm can fund the optimal investment level I^* using credit lines as well.[13]

3.3. The Choice Between Cash and Credit Lines

Although it is easy to understand why derivatives are an imperfect substitute for cash holdings, it is less obvious how firms should choose between cash and credit lines in their liquidity management.

[12]Many other insurance-like characterizations can be found in the literature. Maksimovic (1990) provides a rationale based on product market competition, where a credit line allows the firm to expand when an investment opportunity arises, and this commitment threatens industry rivals. Berkovitch & Greenbaum (1991) propose a model in which lines of credit provide insurance against variations in required investment.

[13]An important question we do not discuss here is why credit lines are provided solely by banks and not by other investors. A possible answer is that there are synergies between the deposit-taking and the credit line–providing roles of banks (see, e.g., Kashyap, Rajan & Stein 2002; Gatev & Strahan 2006; Gatev, Schuermann & Strahan 2007).

In an important survey conducted among the CFOs of 29 countries, Lins, Servaes & Tufano (2010) report that managers use cash savings as a way to hedge against negative cash flow shocks, whereas credit lines are used to enhance their firms' ability to exploit future business opportunities. Although their survey instrument allows Lins, Servaes & Tufano (2010) to identify clear differences in the way managers see cash and credit lines, it does not allow the authors to identify the trade-offs involved in their choices. Analyzing these trade-offs requires a characterization of the costs and benefits associated with those alternative liquidity management instruments.[14]

3.3.1. Liquidity premia. In the literature related to corporate liquidity, the deadweight cost of cash holdings often arises from a liquidity premium. (We discuss other costs of carrying cash, such as free cash problems and taxes, below.) Firms tend to hold their cash balances in safe and liquid assets that are directly or implicitly backed by the government, such as US Treasury bonds. In fact, as Holmstrom & Tirole (1998) argue, there are good reasons for firms to hold government-backed assets. If the purpose of holding cash is to ensure financing capacity in bad states of the world, then firms should hold assets whose payoff is independent of the state of nature. Government bonds, such as US Treasuries, are likely to satisfy this condition because they are backed by the government's ability to tax and thus transfer pledgeable income from individuals to the corporate sector. Probably because of this feature, US Treasuries tend to trade at a premium relative to other assets that appear to have similar credit risk. (See Krishnamurthy & Vissing-Jorgensen 2012 for evidence of a liquidity premium and how it varies with the supply of Treasury bonds.)

This liquidity premium can be captured in the model above by assuming that liquid assets trade at date 0 at a price q greater than one. Thus, holding $(\rho - \rho_0)I$ in cash to fund continuation at date 1 requires the firm to pay $q(\rho - \rho_0)I$ at date 0. The liquidity premium will reduce the feasible investment level and reduce the firm's payoff:

$$\begin{aligned} I^C &= \frac{A}{1 - \rho_0 + \lambda\rho + (q-1)(\rho - \rho_0)} \\ U^C &= \left[\rho_1 - \lambda\rho - 1 - (q-1)(\rho - \rho_0)I^C\right] \end{aligned} . \tag{14}$$

So if $q > 1$, $I^C < I^*$ and $U^C < U^*$.

3.3.2. Credit line revocation. A possible cost of credit line–based liquidity insurance is proposed by Sufi (2009). Real-world credit line contracts contain covenants that allow banks to restrict credit line drawdowns if covenants are violated. Sufi provides evidence that access to credit lines is restricted following covenant violations and that such violations typically follow declines in firm profitability.[15]

[14]Because both cash and credit lines introduce additional frictions, it is possible that firms will also adjust real investments because of liquidity management considerations. Almeida, Campello & Weisbach (2011) present a model showing how firms facing liquidity management frictions may display a bias toward short-term, tangible, and safe real investments.

[15]The so-called material adverse clause (MAC) often found in credit line agreements allows banks to renege on those funds. Boot, Greenbaum & Thakor (1993) provide an endogenous rationale for why banks use MAC clauses and what kind of banks will resort to them. Thakor (2005) provides a theoretical rationale for why borrowers purchase loan commitments, despite the MAC clause. Shockley & Thakor (1997), however, argue that MAC clauses are rarely invoked. Moreover, evidence provided by Roberts & Sufi (2009) and Nini, Smith & Sufi (2009), among others, show that firms and banks tend to renegotiate contractual clauses leading to the suspension of borrowing facilities. Campello et al. (2011a) further show that during the 2008–2009 Financial Crisis, banks were more forgiving of firms in violation of their credit line agreements. Very few were terminated, with the vast majority simply renegotiated to reflect the more adverse conditions of the overall economy at the time.

To capture the impact of credit line revocation in the model above, we assume that in state λ there is a probability $z > 0$ that the firm will not be able to draw on the credit line. (This formulation follows Almeida, Campello & Hackbarth 2011.) If this happens, the firm is liquidated. With this change, we have that

$$I^{LC} = \frac{A}{1 - \rho_0 + \lambda\rho - \lambda z(\rho - \rho_0)}$$
$$U^{LC} = \big[\rho_1 - \lambda\rho - 1 - \lambda z(\rho_1 - \rho)\big] I^{LC}. \tag{15}$$

We have $I^{LC} > I^*$, but $U^{LC} < U^*$. Credit line revocation increases date-0 pledgeable income for the firm and allows it to invest more. But it creates costly liquidation and reduces the payoff per unit of investment. (We can show that Equation 4 implies that the total payoff decreases, $U^{LC} < U^*$. In particular, U^{LC} decreases with the probability of revocation z.) Given Equations 14 and 15, the firm chooses cash (credit lines) if $U^{LC} < (>)\ U^C$.

Equation 15 also highlights one of Sufi's main points. The cost of credit line revocation is higher for firms that have a high risk of facing a liquidity event (high-λ firms). Thus, firms that are less profitable or that have greater cash flow risk are more likely to use cash for their liquidity management, despite the presence of a liquidity premium.

In the formulation above, the probability of credit line revocation z is exogenous. Acharya et al. (2014) propose a model in which credit line revocation arises endogenously as a mechanism to control agency problems induced by liquidity insurance. They show that firms with high liquidity risk are more likely to choose cash over credit lines for their liquidity management because the cost of monitored liquidity insurance is higher for risky firms. [The monitoring role of banks provides a rationale for why credit line–based liquidity insurance is more widely available than (arms' length) derivatives-based insurance.]

3.3.3. The role of bank liquidity. An important feature of credit line–based liquidity management is that it relies on the ability of the banking sector to honor credit line drawdowns. As noted by Holmstrom & Tirole (1998), there can be a shortage of liquidity in the banking sector if firms' liquidity requirements are correlated. To see why, suppose that there is a measure of firms in the economy that are identical in all aspects but the correlation of their liquidity shocks. A fraction θ of these firms have perfectly correlated liquidity shocks, and the remaining firms have perfectly idiosyncratic liquidity shocks. (This formulation follows Acharya, Almeida & Campello 2013.) If all these firms choose to manage their liquidity through the banking sector using credit lines, the banking sector will face the following aggregate liquidity constraint:

$$(1 - \theta)(1 - \lambda)\rho_0 \geq \big[\theta + (1 - \theta)\lambda\big](\rho - \rho_0). \tag{16}$$

Conditional on an aggregate liquidity shock, there are $(1 - \theta)(1 - \lambda)$ firms supplying pledgeable income ρ_0, but $\theta + (1 - \theta)\lambda$ firms that need liquidity injection $\rho - \rho_0$. If this constraint fails to hold, firms cannot rely solely on credit lines for their liquidity management even if credit lines dominate cash for each individual firm. As Holmstrom & Tirole point out, the solution is to bring outside liquidity into the picture, in the form of government bonds that are held as cash reserves by the corporate sector or banks.[16]

[16] An alternative solution is to have the government inject liquidity ex post conditional on an aggregate liquidity shock. Holmstrom & Tirole (2011) use this insight to discuss government intervention during the recent financial crisis.

Acharya, Almeida & Campello (2013) use this insight to derive additional predictions about the choice between cash and credit lines. They show that the most efficient allocation of liquidity is one in which firms with idiosyncratic liquidity risk use credit lines, whereas firms with correlated liquidity risk use cash in addition to credit lines. Provided that firms' exposure to aggregate risk is observable, their model predicts that firms with greater aggregate risk exposure should hold more cash for their liquidity management, and that aggregate cash holdings should increase with economy-wide aggregate risk.

In Holmstrom & Tirole (1998) and Acharya, Almeida & Campello (2013), there is no role for credit line revocation, and thus credit lines are fully committed in equilibrium. (Banks manage aggregate risk exposure ex ante by not writing credit lines, rather than ex post by restricting access to existing lines following negative aggregate shocks.) However, bank liquidity and credit line revocation can also interact in interesting ways. Because credit line drawdowns are implicitly backed by banks' liquidity positions, firms face the risk that liquidity-constrained banks can use covenant violations to revoke access to credit lines even in situations when covenant violations should be waived. Thus, credit line revocations (the probability z in the model above) can also happen because of bank-specific shocks that are unrelated to firm-specific variables. Bank shocks can thus provide an additional reason why riskier firms may eschew credit lines and choose to hold cash instead.

4. WHAT IS THE RIGHT MEASURE OF LIQUIDITY?

Despite the existence of alternative ways in which firms can manage liquidity, the bulk of research in corporate liquidity policy has focused on the quantity of cash firms hold in their balance sheets. Most studies use the measure of cash available on COMPUSTAT, cash and cash equivalents, which includes financial instruments such as Treasury bills, money market funds (MMFs), and other financial instruments such as commercial paper and asset-backed securities maturing in at most three months. The underlying assumption is that these kinds of assets are safe and liquid. However, the recent crisis has shown that some of these financial instruments are potentially not as safe as previously thought. For instance, Chernenko & Sunderam (2014) report large runs on money market mutual funds exposed to the Eurozone banks during the 2011 Euro crisis. These runs are potentially surprising given that these funds are permitted to purchase securities from only the highest credit-quality firms.

An example of the way in which the less than perfect safety of MMFs can have real effects on firms occurred with Delta Airlines in 2008. The firm held 33% of its cash in a money market mutual fund called the Reserve Primary fund. This fund "broke the buck" during the 2008–2009 Financial Crisis and froze redemptions. Consequently, in its 2008 10-K, Delta reported a loss of $13 million on its "cash." Other similar incidents highlight that some of the securities on the standard cash and cash equivalents account are risky and potentially will not ensure liquidity for the firm at times it needs it the most, during crisis periods.

In addition, the literature often does not distinguish between cash held in the United States and cash held overseas, for which the firm must pay repatriation taxes to use for investments in the United States. (Ideally, one would want to know exactly how much cash is held abroad, as well as its location, given that repatriation taxes depend on the difference between that country's tax rate and the US rate.) This distinction can alter the conclusions of existing tests significantly for at least two reasons. First, depending on the macroeconomic and political condition of the country, the cash holdings could have different degrees of safety. Second, the cash could be in a jurisdiction with more constrained investment opportunities and nonnegligible costs of bringing the cash regions with better investment opportunities. Therefore, a firm's money could be "trapped" and firms

could be optimizing their cash levels even though, to an outsider, the firm could appear to be holding too much cash.

This logic suggests that elements often considered as cash and cash equivalents in existing research should be revisited. In addition, there are alternative instruments that should be accounted for as firm liquidity. The discussion in Section 3 shows that these alternatives are important, and firms are actively (and simultaneously) substituting cash, lines of credit, and derivatives in their liquidity management. The predominate use of cash and cash equivalents in existing studies may have clouded the literature on liquidity, and at the same time has left open questions deserving of study in future research.

Also, there is a large discrepancy between the COMPUSTAT variable used in most existing studies on corporate liquidity and what firms actually consider to be their cash. To illustrate this point, consider the amount of cash on Apple's balance sheets as of September of 2012. Using the COMPUSTAT variable, it would appear that Apple had only $29.1 billion of cash on its books. However, as numbers from Apple's 10-Ks show (see **Table 1**), that quantity does not represent what Apple and its investors considered to be cash on hand at their disposal. In fact, Apple considered its total cash to be $120.2 billion ($82.6 billion are held overseas). This number was the subject of several news articles about Apple's cash and was discussed and justified multiple times on Apple's 10-Ks. The number Apple's managers and investors anticipate with regard to their liquidity management is extremely different from those which researchers use on their analyses. The discrepancy between what econometricians and economic agents see as corporate cash potentially affects many firms, not just Apple.

Improving upon the variable available on COMPUSTAT as a measure of liquidity is difficult because of data limitations. For example, data on foreign cash holdings that are costly to repatriate are not available because firms are not required to disclose the fraction of cash that is held in low-tax jurisdictions. Firms are also not required to disclose how much cash is tied to operations, or in which securities they invest their cash. Data on undrawn portions of credit lines for large samples have only recently become available (Sufi 2009, Ippolito & Perez-Orive 2012, Acharya et al. 2014).

Despite this caveat, it is possible to provide a somewhat more complete picture of corporate liquidity by using currently available data to incorporate information on credit lines. Sufi's (2009) data, which comprise a random sample of 300 firms between 1986 and 1993, suggest that undrawn credit lines represent approximately 10% of assets and are almost as large as cash holdings. These numbers suggest that credit lines are quantitatively as important as cash for corporate liquidity management.

In addition, given that cash and credit lines are not mutually exclusive, total liquidity held by firms in the form of cash and credit lines is even larger than numbers reported by most studies. **Table 2** uses the dataset provided by Ippolito & Perez-Orive (2012), which is based on a sample of firms that have data available on both COMPUSTAT and Capital IQ (the source of credit line data), between 2002 and 2010. Firms that have access to credit lines have an average undrawn credit line-to-assets ratio of approximately 0.09 to 0.10, but they also hold cash (their average cash ratios range between 0.13 and 0.15 of book assets during this time period). In turn, firms without a credit line have significantly more cash (cash-to-assets ratios between 0.3 and 0.42). Thus, firms with credit lines have significantly more liquidity than if we consider only the average cash ratio in the sample (which fluctuates between 0.2 and 0.24).

Finally, more information is becoming available that could potentially improve our measures of liquidity. Firms started releasing details on their cash investments, which could help us understand how much risk firms' cash holdings are exposed to, especially during market downturns.

Table 1 Apple's cash, cash equivalents, and marketable securities as reported on Form 10-K for the fiscal year ended September 29, 2012

	Adjusted cost	Unrealized gains	Unrealized losses	Fair value	Cash and cash equivalents	Short-term marketable securities	Long-term marketable securities
Cash	$3,109	$0	$0	$3,109	$3,109	$0	$0
Level 1:							
Money market funds	1,460	0	0	1,460	1,460	0	0
Mutual funds	2,385	79	(2)[a]	2,462	0	2,462	0
Subtotal	3,845	79	(2)	3,922	1,460	2,462	0
Level 2:							
US Treasury securities	20,088	21	(1)	20,108	2,608	3,525	13,975
US agency securities	19,540	58	(1)	19,597	1,460	1,884	16,253
Non-US government securities	5,483	183	(2)	5,664	84	1,034	4,546
Certificates of deposit and time deposits	2,189	2	0	2,191	1,106	202	883
Commercial paper	2,112	0	0	2,112	909	1,203	0
Corporate securities	46,261	568	(8)	46,821	10	7,455	39,356
Municipal securities	5,645	74	0	5,719	0	618	5,101
Mortgage- and asset-backed securities	11,948	66	(6)	12,008	0	0	12,008
Subtotal	113,266	972	(18)	114,220	6,177	15,921	92,122
Total	$120,220	$1,051	$(20)	$121,251	$10,746	$18,383	$92,122

[a]Negative amounts are reported in parentheses.

In addition, more researchers are exploring segment data to incorporate the effects of cash held overseas on the firm's optimal cash level.

5. AGENCY COSTS OF LIQUIDITY

The flexibility provided by cash holdings can also have a dark side. As Jensen (1986) originally proposed, excess liquidity can lead managers to waste resources in bad projects if managers have private benefits of control. Consider again the model presented in Section 2. The model's optimal solution requires cash to be returned to investors in state $1 - \lambda$ given that there is no need to make a continuation investment in that state. However, it is likely that the manager's incentives could lead him to invest in bad projects rather than to return the cash to investors in the good states of the world.

To see how this is reflected in the model, assume that in addition to the project, the firm's manager has access to an alternative project that produces a payoff R' per unit of investment that obtains with probability p (same as above), and with probability $1 - p$ produces nothing. The probability of success depends on the input of specific human capital in a similar way as we

Table 2 Time series evolution of cash holdings, undrawn credit, and total liquidity

	Full sample		Firms with a credit line				Firms without a credit line	
Year	Obs.	Average cash ratio	Obs.	Average cash ratio	Average undrawn credit ratio	Average liquidity ratio	Obs.	Average cash ratio
2002	4,230	0.218	2,079	0.135	0.146	0.281	2,131	0.3
2003	4,276	0.231	2,816	0.146	0.144	0.291	1,445	0.399
2004	4,265	0.238	2,810	0.151	0.140	0.291	1,439	0.408
2005	4,276	0.241	2,851	0.152	0.148	0.3	1,414	0.42
2006	4,175	0.239	2,797	0.148	0.142	0.29	1,372	0.425
2007	4,027	0.237	2,713	0.142	0.138	0.28	1,308	0.436
2008	4,076	0.219	2,691	0.132	0.138	0.27	1,378	0.39
2009	3,987	0.236	2,616	0.151	0.140	0.292	1,356	0.4
2010	3,500	0.238	2,328	0.148	0.140	0.288	1,148	0.421

This table provides summary statistics related to the cash ratio [cash and marketable securities (Compustat #1) over total assets (Compustat #6)], the undrawn credit ratio (undrawn credit over total assets), and the total liquidity ratio (cash and marketable securities plus undrawn credit over total assets) over the period 2002–2010. The sample includes all US firms covered by both Capital IQ and Compustat from 2002 to 2010 with positive values for the book value of total assets and sales revenue, excluding financial firms (SIC codes 6000–6999) and utilities (SIC codes 4900–4999). Abbreviation: Obs., number of observations.

modeled above. If the managers exert high effort, the probability of success is equal to p_G. Otherwise, the probability is p_B, but the managers consume a private benefit equal to $B' < B$ per unit. This project does not require a continuation investment ρ as above, and it has negative NPV:

$$pR' < 1.$$

Clearly, the manager should not invest in such a project and will not be able to raise external financing to do so given that the project has negative NPV. In addition, the manager has no incentive to invest net worth A into this project at date 0, given that it produces a lower NPV and lower private benefits per unit than the good project ($0 < B' < B$). However, the manager could have an incentive to redirect cash holdings into this project at date 1, if cash is not needed to fund the good project.

Consider the incentives of the manager in state $1 - \lambda$ when the firm has cash holdings equal to C^*. If the manager keeps the cash in the firm (as specified by the optimal contract above), her payoff is zero. But if the manager decides to invest the cash in the bad project, she will receive a payoff equal to $\frac{B'C^*}{\Delta p} > 0$. Given that the manager starts the project, investors can either pay the manager enough so that the manager exerts effort to complete the project or pay the manager nothing, in which case the manager will shirk and consume the private benefit. In either case the minimum payoff for the manager is $\frac{B'C^*}{\Delta p} > 0$.

It is difficult to find simple contractual solutions that maintain the value of cash in bad states of the world, while at the same time restricting its usage when it is not needed. For example,

introducing a short-term debt payment that is senior to investment expenditures in the model will force the firm to pay out cash in state $1 - \lambda$ but can cause inefficient liquidation in state λ. Making investment senior to short-term debt can reintroduce the free cash flow problem in state $1 - \lambda$. Covenants on long-term debt that restrict investment share the same tension. They help contain free cash flow problems, but can also reduce flexibility in light of a genuine negative shock.

In practice, firms are likely to rely on other governance mechanisms to fine-tune their liquidity. For example, debt investors may use covenant violations to renegotiate with firms and help select valid uses of firms' cash reserves (Chava & Roberts 2008; Roberts & Sufi 2009; Nini, Smith & Sufi 2009). Monitoring by large shareholders in private firms (Gao, Harford & Li 2013), country-level investor protection (Dittmar, Mahrt-Smith & Servaes 2003), and pressure from the control market if a firm lacks antitakeover provisions (Harford, Mansi & Maxwell 2008; Yun 2009) can also help assure that firms do not waste their liquidity in bad projects.

Because it is difficult to fine-tune the use of liquidity perfectly, free cash flow problems remain a distinct possibility. The free cash flow problem can become even more serious when firms hold excess cash. (Starting with Opler et al. 1999, the literature usually proxies for excess cash holdings by calculating the residual cash that cannot be explained by a regression model predicting cash holdings.) In the model above, the free cash flow problem arises from an (ex post) waste of ex ante optimal cash holdings (C^*), in a state of the world where cash is not required and should be returned to investors.[17]

There is some evidence that excess cash leads to value destruction. Harford's (1999) results suggest that firms that hold excess cash are more likely to attempt acquisitions of other firms. These acquisitions are more likely to be diversifying and tend to lead to declines in operational performance and destruction of shareholder value. Harford, Mansi & Maxwell (2008) find that wasteful investments occurring because of excess cash are more likely to happen when firms have poor corporate governance [as proxied by Gompers, Ishii & Metrick's (2003) G-index]. Cunha (2014) finds that value-destroying acquisitions due to excess cash are significantly less likely when firms raise cash from financing sources such as debt issuance. Cash holdings that are actively raised by firms are more likely to be the result of optimal liquidity management decisions. In contrast, excess cash that is passively accumulated through operational surpluses does appear to lead to value-destroying acquisitions, consistent with the free cash flow argument.

6. REAL IMPLICATIONS OF CORPORATE LIQUIDITY

Our theoretical framework revolves around the impact of liquidity on real corporate policies. We use a generic form of investment, I, to represent those policies. Arguably, the most natural form in which these policies manifest themselves is in the form of capital expenditures. This argument can be broadened to include much other research in financial economics, including models relating investment and firm cash flows (see, e.g., Fazzari, Hubbard & Petersen 1988; Kaplan & Zingales 1997; Rauh 2006; Almeida & Campello 2007).

There exists a growing literature on the real implications of corporate liquidity. Liquidity management is at the heart of corporate policy and corporate liquidity has been examined in conjunction with issues going from collective bargaining and unionized labor (Klasa, Maxwell & Ortiz-Molina 2009) to product market competition (Fresard 2010). Work on corporate liquidity has also covered topics ranging from investment in R&D (Brown, Fazzari & Petersen 2009) to

[17]The impact of agency issues on firms holding excess cash is mitigated somewhat if managers internalize the future costs of wasting cash when making liquidity management decisions.

M&As (Almeida, Campello & Hackbarth 2011). To keep our review manageable, we selectively discuss a few of these topics.

6.1. Liquidity and Acquisitions

One of the first papers to systematically study the use of cash stocks in acquisitions was Harford (1999). As discussed above, his results can be seen as evidence of the agency problems associated with cash holdings. However, agency problems are not the only channel through which corporate liquidity can affect acquisitions. Almeida, Campello & Hackbarth (2011) study the way in which acquisitions can reallocate liquidity across firms in a given industry. The authors propose a theory explaining why distressed firms could be acquired by relatively liquid firms, even in the absence of operational synergies. Their theory further examines how firms choose between cash and credit lines as the optimal source of liquidity to fund these transactions. The idea underlying this model is that acquirers in the same industry are in a privileged position to acquire their distressed targets because they can access some of the income of the target that is nonpledgeable to industry outsiders.[18] However, time-consistency considerations imply that acquirers have to make their funding arrangements ex ante. Almeida, Campello & Hackbarth (2011) then show that the optimal solution is to finance the acquisition with credit lines. In their empirical analysis, the authors confirm the predictions of the theory and find that higher asset specificity in an industry is associated with more liquidity mergers. Moreover, firms are more likely to use lines of credit to pay for the acquisition if they operate in industries with specific but transferable assets.

Another line of research relates financial constraints to the issue of cash and acquisitions. Erel, Jang & Weisbach (2014) explore the effects of mergers on the financial conditions of the target, as measured by cash policies. Using data from firm subsidiaries, the authors observe measures of financial constraint of the target firm before and after the acquisition. In particular, the authors report that following acquisitions, both the cash holdings and the cash flow sensitivity of cash of the target firms decline sharply, with more pronounced declines for ex ante financially constrained targets. The findings of Erel, Jang & Weisbach (2014) relate to those of Duchin (2010), who reports that conglomerate firms carry less cash in their balance sheet for hedging and constraints motives.

6.2. Liquidity and Product Market Competition

One of the most important dimensions of corporate policies is the way firms interact with other firms, customers, employees, suppliers and other agents in their product markets. A well-established literature has examined the impact of financial policy on product market interactions, but the primary focus of that literature, both theoretical and empirical, has been on debt policies (e.g., Brander & Lewis 1986; Bolton & Scharfstein 1990; Chevalier 1995a,b; Phillips 1995; Campello 2003). In recent years, however, researchers have reported evidence on the importance of liquidity management in influencing, and responding to, dynamics arising from product market interactions.

Haushalter, Klasa & Maxwell (2007) and Fresard (2010) document the way in which liquidity management and product market behavior can interact with one another. Fresard (2010) studies whether cash reserves can increase a firm's strategic aggressiveness. Using a variety of empirical

[18]In terms of the model in Section 2, same-industry firms are willing to acquire a firm j that cannot pay for the liquidity shock ρI because they can produce cash flows greater than zero (though lower than $\rho_1 I$) from the assets of firm j.

identification strategies dealing with the endogeneity of firms' cash positions, he finds that firms with more cash tend to gain market shares. This effect is robust to the inclusion of the debt effect discussed above and is more pronounced in industries in which the rival has a harder time getting access to external financing. Haushalter, Klasa & Maxwell (2007) consider the same problem from the perspective of the way corporate policies adapt to industry conditions. The authors show that product market considerations influence corporate cash and hedging policies in significant ways. In particular, the higher the risk of predation, the more the firm will save and hedge with derivatives.

Morellec, Nikolov & Zucchi (2014) also study the interactions between cash and product market performance. These authors present a model where financial constraints play a key role: Firms in more competitive industries have to hold more cash to survive, with this effect being more pronounced in the presence of financial constraints. Using empirical strategies that resemble Fresard (2010), Morellec, Nikolov & Zucchi (2014) show that high levels of industry competition are usually associated with more pronounced cash hoarding behavior by firms (see also Fresard & Valta 2013). The authors' work allows them to propose a partial, Industrial Organization–based explanation for the secular increase in cash holdings documented in Bates, Kahle & Stulz (2009), by showing that there is no such secular trend in concentrated industries. Hoberg, Phillips & Prabhala (2014) explore an innovative measure of competitiveness and report largely similar results. Using textual analysis of product descriptions to measure competitive threats, the authors document a strong relation between competition and cash holdings.

Work on the interplay between liquidity management and product market behavior can be extended in several directions, including the issue of conglomeration. For example, Boutin et al. (2013) use data on French conglomerates to study the way in which a business group's cash holdings affect the competitiveness of its affiliates. They find that the group's cash position significantly affects the probability of a new entry. For instance, industries in which incumbents are part of a group with deep pockets are less likely to observe entry. In addition, firms that belong to deep-pocket business groups are more likely to enter in a new market.

In general, work on product market interaction highlights the beneficial effects of cash. This contrasts sharply with the finding of the existing literature on the agency problems of cash discussed in Section 5.

7. THE VALUE OF LIQUIDITY WHEN CAPITAL MARKETS FAIL

The relation between corporate liquidity and real investment came to the forefront of academic and policy debate during the 2008–2009 Financial Crisis. The breakdown in credit markets started in the fall of 2007 and became acute in the spring of 2009. Firms' inability to obtain liquidity on demand in the credit markets allowed researchers to look at corporate liquidity management at a time when liquidity was particularly scarce.

An evolving stream of research is currently examining the impact of the 2008–2009 Financial Crisis on corporate behavior. Given the time it takes for data to appear, we do not yet fully understand the long-term consequences of the crisis in shaping liquidity management. However, a number of papers produced to date set up the agenda for future research.

One of the first papers to examine liquidity scarcity during the 2008–2009 Financial Crisis was Ivashina & Scharfstein (2010). Their focus was on the impact of the crisis on bank lending. The key insight of their paper comes from a simple observation: Although the origination of new loans fell nearly 50% by the fall of 2008, lending for real investments fell by only 14%. The authors show that this puzzling fact occurs because many firms drew from their pre-existing credit lines at the onset of the crisis. Ivashina & Scharfstein document a new type of run, companies drawing down

their lines in anticipation of a drought to guarantee their liquidity needs during the crisis. [The effect of the crisis on the supply of liquidity (credit lines and commercial papers) to firms in the United States is further documented by Gao & Yun 2013].

Although the Ivashina & Scharfstein paper looks at corporate lending by banks in the 2008–2009 Financial Crisis, it does not gauge the real effects of the liquidity shortage managers were facing at that time, which is analyzed by Campello, Graham & Harvey (2010). During the fall of 2008, the authors sent out surveys to 1,050 CFOs in 39 countries inquiring about their corporate plans for the coming year. These data provide Campello, Graham & Harvey with forward-looking information on corporate liquidity management. The authors report that, as a consequence of the crisis, financially constrained firms had plans to cut their cash stocks by as much as 15 percentage points, compared to only 2 percentage points across financially unconstrained firms. In the United States, the pronounced planned cuts in liquidity were accompanied by other changes in corporate policies for constrained firms. In particular, those firms reported plans to dramatically reduce employment (by 11%), technology spending (by 22%), capital investment (by 9%), and dividend payments (by 14%) in 2009. Financially unconstrained firms, in contrast, reported much milder changes in their planned policies for 2009.

An important issue concerning liquidity management during the 2008–2009 Financial Crisis was the extent to which various forms of liquidity management helped companies deal with the collapse of the market. Duchin, Ozbas & Sensoy (2010) consider this issue by examining the way in which firms' cash holdings affect the impact of the crisis on firms' investment. The authors report that corporate investment declines significantly at the onset of the crisis, even controlling for time-varying measures of investment opportunities. Consistent with a causal effect of a supply shock, Duchin, Ozbas & Sensoy (2010) further show that the decline is greatest for firms that have low cash reserves. The authors argue that the "seemingly excess cash" held by firms may well be motivated by precaution against credit supply shocks (Duchin, Ozbas & Sensoy 2010, p. 418).[19]

Kahle & Stulz (2013) question the view that a supply-side shock caused the decline in investment during the 2008–2009 Financial Crisis. These authors hypothesize that bank-dependent firms should be the most affected by a credit shortage. In the data, however, they find that bank-dependent firms did not invest less than other firms during the crisis. Importantly, the authors find that, rather than becoming cash-starved, bank-dependent firms managed to accumulate more cash than other firms in the crisis. Kahle & Stulz conclude that financing, liquidity, and investment policies observed right before Lehman's failure in 2008 do not imply that a bank lending shock had causal, first-order effects on corporate outcomes.

Campello et al. (2011a) try to gauge the various dimensions of corporate liquidity management during the 2008–2009 Financial Crisis. Using a questionnaire focusing on credit lines, the authors report that small, private, noninvestment grade, and unprofitable firms drew significantly more from their credit lines during the crisis. The authors also examine how firms' cash flows impacted their access to credit lines and their savings during the crisis. In contrast to Sufi (2009), they find that inferences about a positive impact of cash flows on credit lines are relevant only for firms with low cash. Campello et al. (2011a) also study the role cash and credit lines play in minimizing the impact of the crisis on corporate investment. They find that firms with more cash had their investment plans boosted by greater access to credit lines. That relation was reversed for firms with little or no access to credit lines. The authors report that lack of access to credit lines forces firms to choose between

[19]Relatedly, Jang (2013) argues that having access to multiple sources of capital can serve as insurance against shocks to the capital market. She documents that multinational firms were able to draw on resources from other countries to mitigate supply shocks in the United States caused by the 2008–2009 Financial Crisis.

saving and investing when outside liquidity is scarce. The overall implication is that access to credit lines was crucial in allowing firms to invest (and survive) during the 2008–2009 Financial Crisis.

8. CONCLUDING REMARKS

Although liquidity management has always been a key element of financial managers' jobs, it has only recently become an important topic of research in corporate finance. The literature on liquidity management has addressed several topics, including the factors that affect how liquid firms' balance sheets are, the extent to which firms' savings from incremental cash flows reflect firms' financial constraints, the choice between holding cash and other ways firms ensure future liquidity, the ways in which liquidity can lead to agency problems between managers and shareholders, the effect of firms' liquidity on their real decisions, and the role of corporate liquidity during the 2008–2009 Financial Crisis. We discuss these literatures using a framework in which firms have a precautionary demand for liquidity because of financial constraints arising from an underlying moral hazard problem.

Although much has been learned about corporate liquidity management in recent years, there are several unresolved issues that could be addressed by future research. We do not yet have a complete explanation for the dramatic increase in the ratio of cash over assets in recent years. A key to understanding this pattern could be changes in other markets relevant to liquidity management such as credit lines and derivatives. The extent to which the increase in liquidity extends to all instruments would provide further evidence that corporations increased their precautionary demand for liquidity over time. Data on these alternate liquidity instruments have improved recently, so it may become possible to conduct this exercise in the near future. Even with currently available data, future research will benefit from considering corporate liquidity in a broader sense, encompassing not only cash but also potential substitutes.

Future research can also strengthen our understanding of corporate cash holdings by gathering further details about the way in which firms hold cash. Two important dimensions that are poorly understood are the fraction of cash that is held abroad (possibly for tax reasons) and the makeup of what is referred to as firms' cash among different types of securities. Understanding the determinants and the magnitudes of foreign cash and cash portfolios could allow researchers to better determine the amount of cash that is truly held for precautionary reasons, as well as the fraction that is held for other reasons.

Research on the real consequences of corporate liquidity has generally taken liquidity as exogenous and has compared firms with high and low (excess) liquidity. Although it is challenging to find appropriate instruments for policy variables such as cash and credit lines, future research should strive to improve the identification of the linkages between liquidity management and real variables such as investment, employment, innovation, valuation, and performance. Given the importance of banks for liquidity insurance provision through credit lines, one promising direction would be to estimate the consequences of shocks to bank liquidity for corporate liquidity and potentially also to real variables.

Factors such as taxes, financing constraints, availability of alternative financing sources, corporate governance, legal and contractual frameworks, and macroeconomic conditions are known to affect corporate liquidity. Empirical work on liquidity should exploit naturally occurring heterogeneity across these dimensions as a way to identify causes and consequences of firms' liquidity policies. Finally, one limitation of the literature on liquidity is that the majority of studies on corporate liquidity are based on samples of US firms. As new data from other economies become increasingly available, future research should evaluate the extent to which the patterns observed in the United States occur in other countries as well.

Financial managers must decide both how much liquidity to hold and the way in which they hold this liquidity. New developments in financial markets such as more liquid derivatives markets complicate these decisions, and the 2008–2009 Financial Crisis highlighted their importance. Not surprisingly, therefore, liquidity management has become an important research topic in corporate finance. We have surveyed some of the more important work studying liquidity management decisions. Given the topic's importance, the open questions we have identified in the discussion above and developments in financial markets that have affected the way that firms manage liquidity, we suspect that liquidity management will continue to be an active topic of research in the future.

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Appendix: The Model with Decreasing Returns to Scale

Assume that investment produces a payoff equal to $R(I)$ with probability p_H if it is continued until the final date, where the function $R(.)$ exhibits decreasing returns to scale ($R' > 0$, $R'' < 0$). With probability $1 - p_H$, the project produces nothing. The project's pledgeable income is now

$$\rho_0(I) \equiv p_H\left[R(I) - \frac{BI}{p_H - p_L}\right]. \tag{17}$$

In the constant returns to scale model, it was optimal to withstand the liquidity shock in state λ whenever $(1-\lambda)\rho < 1$. To derive a similar condition for this version of the model, we compute the optimal investment for the firm continuing in state λ or not, and then compare the payoffs.

Assuming it is optimal to survive the liquidity shock ρI in state λ, the firm solves the following optimization problem:

$$\max p_H R(I) - (1+\lambda\rho)I \tag{18}$$

s.t.

$$(1+\lambda\rho)I \leq A + \rho_0(I).$$

Thus, the optimal investment level is defined by

$$p_H R'\left(I^{FB}\right) = 1 + \lambda\rho, \tag{19}$$

provided that this investment level obeys the budget constraint, that is, $(1+\lambda\rho)I^{FB} \leq A + \rho_0(I^{FB})$. The associated payoff is

$$U^{FB} = p_H R\left(I^{FB}\right) - \left(1 + \lambda\rho\right) I^{FB}. \tag{20}$$

Similarly, the optimal investment in the case of no continuation satisfies

$$\left(1 - \lambda\right) p_H R'\left(I^l\right) = 1, \tag{21}$$

provided that $I^l \leq A + (1 - \lambda)\rho_0(I^l)$.[20] The associated payoff is

$$U^l = \left(1 - \lambda\right) p_H R\left(I^l\right) - I^l. \tag{22}$$

So it is optimal to withstand the liquidity shock if

$$U^{FB} - U^l = \lambda\left[p_H R\left(I^{FB}\right) - \rho I^{FB}\right] + \left(1 - \lambda\right) p_H R\left(I^{FB}\right) - I^{FB} - U^l > 0. \tag{23}$$

The term $(1 - \lambda)p_H R(I^{FB}) - I^{FB} - U^l$ is negative given that $U^l = \max(1 - \lambda)p_H R(I) - I$. Thus, the optimality of continuation requires that $\lambda\left[p_H R(I^{FB}) - \rho I^{FB}\right]$ is positive and large. As in the model above, this condition is more likely to hold when λ is large and ρ is small.

Assume that Equation 23 holds, so that continuation in state λ is optimal (this means that I^{FB} is indeed the first-best investment level). As in the model above, liquidity management is necessary when pledgeable income in state λ is not sufficient to fund the liquidity shock:

$$\rho_0\left(I^{FB}\right) < \rho I^{FB}. \tag{24}$$

If this holds, then the firm will have a precautionary demand for liquidity.

Consider now the case in which the first-best investment level I^{FB} is not feasible, that is, $(1 + \lambda\rho)I^{FB} > A + \rho_0(I^{FB})$. In this case, the firm needs to change its optimal policy. One option is to maintain the liquidity management policy, but to reduce investment to the level that satisfies the budget constraint:

$$(1 + \lambda\rho)I^* = A + \rho_0(I^*), \tag{25}$$

obtaining the payoff

$$U^* = p_H R(I^*) - (1 + \lambda\rho)I^*. \tag{26}$$

Clearly, $U^* < U^{FB}$, and $I^* < I^{FB}$.

Another option that the firm has is not to continue the project in state λ, which will save pledgeable income given Equation 24. Eliminating liquidity management frees up resources that can be used to increase date-0 investment and relax financing constraints. Thus, the trade-off that the firm faces is to increase investment above I^* by eliminating liquidity management or save enough liquidity by investing I^* and continue in state λ. The difference in payoffs in this case is

$$U^* - U^l = \lambda\left[p_H R(I^*) - \rho I^*\right] + \left(1 - \lambda\right) p_H R\left(I^*\right) - I^* - U^l. \tag{27}$$

The key net worth effect identified by Rampini & Viswanathan (2010) is that the firm is more likely to eliminate liquidity management when net worth (which in this model is captured by A)

[20] We assume that this constraint never binds, but the results also hold when the constraint does bind. In particular, the firm is still more likely to eliminate liquidity management when A is low.

is low. To understand this, notice that the expression $U^* - U^l$ decreases with A. The payoff U^l is independent of A (see Equations 21 and 22), while a decrease in net worth will force the firm to reduce investment I^* and thus the constrained payoff U^*. If A is low enough, the firm may choose to forgo liquidity management completely and achieve the payoff U^l. As stated above, the result is robust to a case in which I^l also decreases with wealth A.

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