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# Is cash negative debt? A hedging perspective on corporate financial policies

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**Abstract**

We show theoretically that while cash allows financially constrained firms to hedge future investment against income shortfalls, reducing current debt is a more effective way to boost investment in future high cash flow states. Thus, constrained firms prefer higher cash to lower debt if their hedging needs are high, but lower debt to higher cash if their hedging needs are low. We provide empirical evidence that supports our theory. Our analysis points to an important hedging motive behind cash and debt management policies. It suggests that cash should not be viewed as negative debt in the presence of financing frictions.


*JEL classification:* G31

*Keywords:* Risk management; Financing frictions; Investment; Cash policy; Debt capacity

## 1. Introduction

Standard valuation models subtract the amount of cash in the firm's balance sheet from the value of outstanding debt in order to determine the firm's leverage. This practice reflects the view of cash as the "negative" of debt: because cash balances can be readily used to redeem debt (a senior claim), only net leverage should matter in gauging shareholders' residual wealth. The

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traditional valuation approach assumes that financing is frictionless and does not assign much of a relevant, independent role for cash holdings in the presence of debt obligations.

In contrast to the traditional view, a number of recent studies show that corporate liquidity is empirically associated with variables ranging from firm value and business risk to the quality of laws protecting investors.[1] These studies imply that cash holdings are a relevant component of the firm's financial structure. However, as pointed out by Opler et al. (1999), most of the variables that are empirically associated with high cash levels are also known to be associated with low debt. The findings that corporate cash holdings are related to variables such as value and risk—although relevant in their own right—cannot differentiate firms' policies regarding cash and debt. In effect, those findings cannot rule out the argument that firms regard cash as negative debt.

This paper proposes a theory of cash–debt substitutability in the optimal financial policy of the firm. We start from the observation that while standard valuation models assume that financing is frictionless, there is ample evidence to suggest that raising funds in the capital markets can be rather costly. Information and contracting frictions often entail high deadweight costs to external financing. And exposure to those costs may affect the way firms conduct their financial and investment policies (e.g., Gomes and Phillips, 2005 and Rauh, 2006a), giving rise to a "hedging motive" (Froot et al., 1993). Building on this argument, we develop a theoretical framework in which cash and debt policies are jointly determined within the firm's intertemporal investment problem. Among the innovations of our theory, we explicitly identify when cash is *not* the same as negative debt. We also characterize circumstances under which cash and debt policies can be used as effective hedging tools. Our study presents novel empirical evidence on the interplay between corporate cash and debt policies, identifying a hedging motive behind financially constrained firms' cash and debt management

Our model considers the process governing a firm's investment demand and the firm's ability to fund investment. We study a firm that has profitable investment opportunities in the future, but that faces limited access to external capital when funding those opportunities. Anticipating these constraints, the firm chooses its current financial policy so as to match up available funds to investment opportunities over time. To achieve this, the firm may boost its cash balances. The firm can do so by saving currently available internal funds or by issuing additional debt. Alternatively, the firm may save debt capacity by using current cash flows to reduce outstanding debt or by avoiding new debt issues. Higher cash stocks and higher debt capacity both increase the constrained firm's future funding capacity, hence the firm's ability to undertake new investment opportunities. Cash and (negative) debt can both be used to transfer resources *across time*.

We show, however, that cash stocks and debt capacity are not equivalent when there is uncertainty about future cash flows. To understand the key intuition, consider a firm that issues risky debt against future cash flows. Because cash flows are risky, the current value of debt will be largely supported by future states of the world in which cash flows are high (the value of debt is higher in high cash flow states). By issuing risky debt today the firm transfers value from future states with high cash flows to the present. By subsequently saving the proceeds from the debt issuance (hoarding cash), the firm channels funds into all future states, including those in which cash flows and debt values are low. In other words, issuing risky debt and keeping the proceeds in the cash account is equivalent to transferring resources from future states with high cash flows into future states with low cash flows. On the flip side, saving/building debt capacity over time is

[1] An incomplete list of papers includes Kim et al. (1998), Harford (1999), Opler et al. (1999), Dittmar et al. (2003), Almeida et al. (2004), Pinkowitz et al. (2005), Hartzell et al. (2005), and Faulkender and Wang (2006).

equivalent to transferring resources into future states with high cash flows. In sum, constrained firms can manage their cash and debt balances so as to transfer resources *across states* in the future. Crucially, cash and (negative) debt perform different functions in the optimization of investment under uncertainty.

The differential effect of cash and debt capacity on investment allows us to derive testable implications about how firms allocate cash flows across their cash and debt accounts. These implications carry naturally on to the real world, where there is uncertainty about the firm's cash flow and investment processes, and where financing is not frictionless. To wit, our theory implies that, because cash balances transfer resources into low cash flow states, a financially constrained firm will prefer saving cash (as opposed to reducing debt) if investment opportunities tend to arrive in low cash flow states. In other words, constrained firms will prefer saving cash if the correlation between cash flows and investment opportunities is low (i.e., when they have "high hedging needs"). In fact, the theory predicts that constrained firms with high hedging needs should display a positive relation between cash flows and debt: higher cash flows increase constrained firms' debt capacity, allowing them to borrow more and carry additional cash balances into the future. In contrast, if the correlation between cash flows and investment opportunities is high ("low hedging needs"), then constrained firms benefit more from allocating a marginal dollar of free cash flow towards debt reductions (i.e., from saving debt capacity). Data from these firms should thus display a negative relation between cash flows and debt, and no significant relation between cash flows and cash holdings.

In our model, firms are indifferent between cash and negative debt in the absence of financial constraints. However, we stress that this indifference only holds in the absence of other costs and benefits that are unrelated to financial constraints.[2] Importantly, even when unconstrained firms display first-order preferences towards cash or debt, our theory can still be identified in the data. The reason is that unconstrained firms' choice between higher cash and lower debt should be independent of considerations about future financing capacity. This observation provides us with an additional identification restriction: while constrained firms' propensity to allocate cash flows towards cash or debt should vary with the correlation between their cash flows and investment opportunities, such sample variation *should not* exist for unconstrained firms.

We test the implications of our theory using a large sample of manufacturing firms drawn from COMPUSTAT over a three-decade period (1971 through 2001). We do so by estimating simultaneous, within-firm responses of cash and debt policies to cash flow innovations across samples capturing the different contrasts proposed by our model. In particular, our financial policy regressions are estimated within samples partitioned both on (1) the likelihood that firms have constrained/unconstrained access to external capital and (2) measures of the correlation between firms' cash flows and investment opportunities (hedging needs).[3] We carefully design our tests to ensure that inferences are robust. Our results are insensitive, for example, to the use of different empirical proxies for the main elements of our theory and to the use of alternative estimation techniques.

Our empirical results can be summarized as follows. First, financially unconstrained firms do not show a propensity to save cash out of cash flows. Instead, consistent with the bulk of the capital structure literature, they use free cash flows towards reducing the amount of debt that they have

[2] For example, unconstrained firms might display a preference towards either cash or debt because of the possibility that cash has a low yield, that cash can be diverted by managers, or that debt provides for tax shields.

[3] As we discuss in Section 4.2, while our measures of financial constraints are quite standard, the measures of hedging needs used in this study are new to the literature.

outstanding. Importantly, as predicted by our model, this pattern holds irrespective of how unconstrained firms' cash flows correlate with investment opportunities. When we look at constrained firms, we find that their propensities to reduce debt and to increase cash are strongly influenced by the correlation between their cash flows and their investment opportunities—hedging needs seem to drive large cross-sectional differences in the optimal balance between cash and debt policies among those firms. To wit, when their hedging needs are low, constrained firms behave somewhat similarly to unconstrained firms: they show a propensity to use excess cash flows to reduce the amount of debt they carry into future periods and display a weak cash flow sensitivity of cash holdings. When constrained firms have high hedging needs, however, they display a strong preference for saving cash (their cash flow sensitivity of cash is positive and highly significant), while showing no propensity to reduce debt. In fact, and as predicted by the model, cash flow sensitivities of debt are positive and significant for such firms. As we discuss below, these results are hard to be reconciled by competing stories.

Our paper is related to several strands of literature and it is important that we establish the contribution of our analysis. Our study is inherently related to the research on corporate hedging. In essence, our main argument is that standard financial policies such as cash and debt can be used to transfer resources across future states of the world—cash and debt can be used as hedging tools.[4] Our contribution to the hedging literature is two-fold. First, we suggest a new dimension in which firms can hedge, other than directly using derivatives. As discussed by Petersen and Thiagarajan (2000), while the hedging literature has focused on the use of derivative instruments, in practice firms use alternative means of hedging that involve both financial and operating strategies. The effectiveness of derivatives might be hampered by the difficulty of securitizing cash flows that are not contingent on easily verifiable variables, such as commodity prices and exchange rates. In contrast, the hedging strategies that we characterize rely only on standard debt instruments, which are arguably available to a much larger universe of firms.

Our second contribution is to report empirical results that support the link between financial constraints and hedging suggested by Froot et al. (1993). Previous attempts to test Froot et al.'s (1993) theory have yielded mixed results, perhaps because those tests have focused mostly on the use of derivatives.[5] Importantly, our paper is one of the first ones to operationalize empirically the notion of hedging needs—the correlation between a firm's cash flows and its investment opportunities. While Froot et al. (1993) also discuss the importance of this correlation in analyzing hedging behavior of firms, our paper is the first to show that hedging needs is the key determinant of whether firms prefer to hedge (i.e., hold cash), or not (i.e., hold spare debt capacity). Providing empirical counterparts to the theoretical notion of hedging needs and demonstrating their effectiveness in understanding the cash versus negative debt question is perhaps the foremost empirical contribution of our paper.

Our paper is also closely related to the literature on cash holdings (see footnote 1). However, our analysis differs from most of the papers in that literature in that we model both cash and debt

[4] The notion that cross-state cash flow transfers can be beneficial for financially constrained firms was first suggested by Froot et al. (1993). Other papers have proposed alternative motivations for hedging, including tax convexity (Smith and Stulz, 1985), debt capacity and associated tax shields (Leland, 1998 and Stulz, 1996), managerial risk-aversion (Stulz, 1984 and Smith and Stulz, 1985), costs of financial distress (Smith and Stulz, 1985), and information issues (DeMarzo and Duffie, 1991). Empirical work testing these hypotheses includes Tufano (1996), Haushalter (2001), Graham and Rogers (2002), and Faulkender (2005). See Petersen and Thiagarajan (2000) for a survey of the literature.

[5] Papers with evidence that speak to the link between financial constraints and hedging include Nance et al. (1993), Mian (1996), Géczy et al. (1997), Gay and Nam (1998), and Guay (1999). The bulk of the evidence suggests that, contrary to intuition, the use of financial derivatives is concentrated in large (likely unconstrained) firms; see Vickery (2004).

policies within an integrated framework. We also characterize theoretically and empirically one element that affects the cash and debt policies of firms facing imperfect capital markets, namely, the intertemporal correlation between cash flows and investment opportunities. Our results show that cash holdings play an important, independent role in the optimization of firm financial policies.

Our empirical approach also relates to the current capital structure literature in that we look at companies' *marginal* external financing decisions (debt issuance and repurchase activities) in order to learn about financial policy-making. Examples of recent papers that use this approach are Shyam-Sunder and Myers (1999), Frank and Goyal (2003), and Lemmon and Zender (2004). These papers are concerned with a firm's choice between debt and equity in the face of an internal "financing deficit" whose calculation takes cash holdings as exogenous. In contrast to those studies, our analysis endogenizes cash holdings, focusing on the cash versus debt margin.

Finally, our study is also related to the large literature on the impact of financial constraints on corporate policies (see Hubbard, 1998 for a review). While earlier studies in that literature focused on firms' capital investments and other *real* expenditures, a few recent papers analyze the impact of constraints on firms' *financial* policies (e.g., Almeida et al., 2004; Faulkender and Petersen, 2006; Faulkender and Wang, 2006; and Sufi, 2006). We contribute to this latter line of research by suggesting an additional financial decision that is directly affected by capital markets imperfections: the choice between cash stocks and debt capacity. For example, Almeida et al. (2004) consider the use of cash reserves as a way for constrained firms to transfer resources across time, but assume that firms can perfectly hedge future cash flows. Thus, their analysis cannot differentiate between cash and debt capacity.[6] Similarly, Sufi (2006) analyzes the usage of lines of credit by firms, but does not consider the dynamic management of cash and debt as we do. We relate our study more closely to the literature on lines of credit in the concluding remarks of the paper.

The paper is organized as follows. In the next section we present a numerical example to explain the basic intuition for why cash and negative debt are not perfect substitutes for financially constrained firms. This example makes several simplifying assumptions so as to make the analysis as transparent as possible. These assumptions are relaxed in the general model of Section 3, where we also explicitly derive and discuss our empirical predictions. Section 4 describes our empirical methods and presents our main findings. Section 5 concludes the paper. Appendix A collects all the proofs.

## 2. An example

We begin with a simple example that captures the essential elements of our theory. Specifically, we consider the optimal financial policy of a firm that has profitable growth opportunities in the future, but that might face limited access to external capital when funding those opportunities. In maximizing investment value, the firm's main financial policy variables are cash and debt.

Figure 1 shows the time line for the model we use in this example. At an initial date (date 0), the firm has cash available (equal to 10 units) and assets in place that will produce a random

6 We further differentiate from Almeida et al. (2004) by showing that their empirical results on financially constrained firms' cash savings behavior are driven by those firms that have high hedging needs. Indeed, we find that constrained firms whose cash flows are highly correlated with investment opportunities (low hedging needs firms) display *no propensity* to save cash out of cash flows.

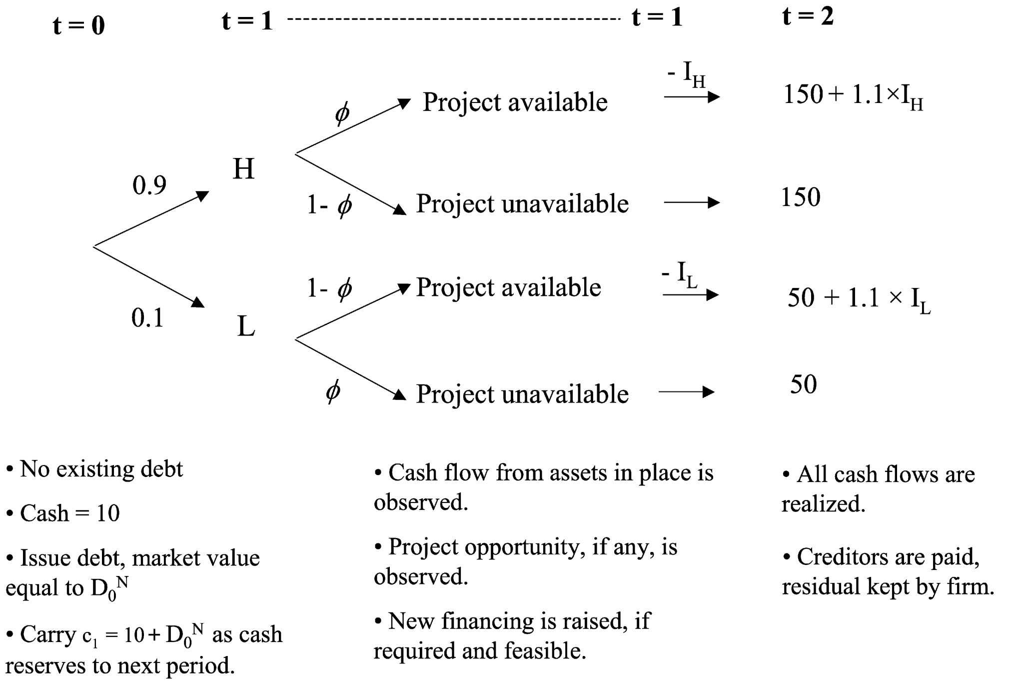


Fig. 1. Timeline for example of Section 2.

cash flow at a future date (date 2). In the good state of nature (state $H$) the cash flow is equal to 150, and in the bad state (state $L$) the cash flow is only 50. The state is realized at an interim date (date 1), and the date-0 probability that state $H$ occurs is equal to 0.9. The firm may be able to make an investment at date 1. This additional investment produces 1.1 units of cash flow for every unit of capital invested. This assumption means that the optimal investment scale is infinite. Whether an investment opportunity is available at date 1 is related with the realization of cash flows from the existing assets. In state $H$, the probability that the new investment opportunity is available is equal to $\phi$. In state $L$, the probability that the investment is available is equal to $(1-\phi)$. Thus, $\phi$ is a measure of the correlation between cash flows from assets in place and investment opportunities.[7]

The firm has no debt at the starting date. In particular, the firm's net debt (market value of debt minus cash) is equal to $-10$. The firm's problem is to maximize the value of its new investments. In the absence of financial constraints, the firm can borrow as much as it wants against the value of the future investment (which is positive NPV), so it can achieve any scale that it desires. In order to introduce financial constraints in the model, we assume that the firm can only pledge

[7] One can think of firms operating in industries where high product demand drives up prices (cash flows) and demand for new capacity (investment opportunities). While intuition suggests that cash flows and investment opportunities are largely positively correlated, research shows that this is not always the case. Conditional on industry characteristics (e.g., ease of entry and competitiveness), a significant fraction of firms may not use industry-core technologies, and thus may not experience higher investment demand when product demand is high; see Maksimovic and Zechner (1991) for a theoretical model and MacKay and Phillips (2005) for empirical evidence. Our empirical analysis will later exploit this sort of variability in the data to test the theory developed in the next section.

a fraction of its date-2 cash flows to outside investors. This pledgeable fraction (which we call $\tau$) is identical for the cash flows that come from assets in place and the cash flows from future investments. Here, we assume $\tau = 0.4$. Finally, the risk-free rate is assumed to be zero.

In this example, the firm chooses whether to issue debt today (date 0) against future cash flows, or to wait and issue debt tomorrow (date 1); that is, after it learns the realizations of cash flows from existing assets and investment opportunities. Because the firm has no use for funds at date 0, it will simply carry any available funds into the future as cash holdings.

### 2.1. *Solution with zero debt*

If the firm chooses not to issue any debt today, it will simply carry a cash balance of 10 into the future. In state $H$, the firm can raise $0.4 \times 150$ in debt against the existing cash flows. The new investment opportunity, if available, produces a cash flow of 1.1 times the amount invested, and generates debt capacity that is 0.4 times this future cash flow. Thus, in state $H$ the firm can invest:

$$I_H = 10 + 0.4 \times (150 + 1.1 \times I_H) \tag{1}$$

which gives $I_H = 125$. This investment happens with probability $\phi$ in state $H$, and produces a NPV of $0.1 \times 125 = 12.5$. In state $L$, the firm has lower debt capacity because cash flows from assets in place are only equal to 50. In that state, the firm invests $I_L = 53.57$, which gives a NPV of 5.36 with probability $(1 - \phi)$.

In sum, if the firm chooses not to issue debt today it is effectively choosing to allow future investment to fluctuate freely with the state of nature. This strategy produces the following expected (date-0) NPV as a function of $\phi$:

$$NPV_1 = 0.9 \times \phi \times 12.5 + 0.1 \times (1 - \phi) \times 5.36. \tag{2}$$

### 2.2. *Solution with date-*0 *debt issuance*

If the firm issues debt at date 0 against future cash flows, it will enter date 1 with existing debt claims, and with additional cash balances. In order to characterize investment levels, we need to make additional assumptions regarding the pledgeability of future cash flows to date-0 creditors, and also regarding priority over the cash reserves that the firm carries into date 1. In this example, we assume that creditors have priority over 40% of the cash reserves. This assumption implies that the firm can use 60% of the cash reserves to fund its future investments. Thus, the cash priority fraction ($\tau^c = 0.4$) is equal to the pledgeable fraction of the cash flows ($\tau = 0.4$). We discuss the priority over cash reserves in detail in Section 3.1.2. To simplify the analysis, we also assume that date-0 debt is backed only by cash flows from assets that already exist at date 0. This assumption is relaxed in the main model of Section 3.

Suppose the firm issues date-0 debt with a face value equal to 100, with payment due at date 2. The debt will be backed by cash flows from existing assets and by the cash reserves that the firm carries at date 1. Importantly, notice that those cash reserves, themselves, depend on the market value of the firm's debt. But how can one determine the value of the firm's debt?

If we call the date-1 cash reserves $c_1$ and the market value of debt $D_0$, we have:

$$c_1 = c_0 + D_0. \tag{3}$$

Now, recall that the firm has no use for cash at date 0 and $c_0 = 10$. Assuming that date-0 creditors break even, the market value of debt can be written as:

$$D_0 = 0.9 \times \min[0.4 \times (c_1 + 150), 100] + 0.1 \times \min[0.4 \times (c_1 + 50), 100]. \tag{4}$$

Notice that while the debt payment is due only at date 2, all uncertainty is resolved at date 1, when the cash flow from existing assets becomes known. As creditors cannot access cash flows from new investments, Eqs. (3) and (4) can be jointly solved to yield $c_1 = 106.25$ and $D_0 = 96.25$. Importantly, note that the debt is fully repaid in state $H$, but not in state $L$ (the value of debt in state $L$ is simply $0.4 \times (106.25 + 50) = 62.5$). This means that the date-0 market value of the debt is supported mostly by the future value in state $H$.

The amount that the firm can invest in each state is given by the sum of cash reserves and future pledgeable cash flows, minus the portion of the pledgeable resources (cash and cash flows) that is captured by date-0 creditors. This portion is equal to the value of the date-0 debt in each state (100 in state $H$, 62.5 in state $L$). In state $H$, we have:

$$I_H = 106.25 + 0.4 \times (150 + 1.1 \times I_H) - 100 = 118.3. \tag{5}$$

A similar calculation for state $L$ yields:

$$I_L = 106.25 + 0.4 \times (50 + 1.1 \times I_L) - 62.5 = 113.84. \tag{6}$$

Comparing these investment levels to those that obtain in the zero debt solution, one can see that by issuing debt at date 0 and carrying the proceeds as cash into date 1, the firm is transferring financing capacity from state $H$ to state $L$. Issuing date-0 debt transfers value from state $H$ into date-0 (because debt value is supported mostly by state $H$), and holding cash transfers the proceeds from issuance to state $L$, where the debt value is low. Notice that the firm's *net leverage* is the same (equal to $-10$) irrespective of the amount of debt issued, but that the feasible investment levels in future states of nature depend on the *gross levels* of cash and debt. In other words, cash is not necessarily equivalent to negative debt: different combinations of cash and debt are associated with different distributions of investment across future states. This is the key insight behind the results of this paper.

For future reference, we denote the NPV equation for the case where the firm issues debt as:

$$NPV_2 = 0.9 \times \phi \times 11.83 + 0.1 \times (1 - \phi) \times 11.38. \tag{7}$$

### 2.3. *Main results*

Whether the firm prefers to carry high cash and high debt, or low cash and low debt depends on the parameter $\phi$. Notice that $\phi$ only affects the model through its effect on the NPV equations (Eqs. (2) and (7)). We can write the difference in our previous NPV equations as:

$$NPV_1 - NPV_2 = 0.6 \times (2\phi - 1). \tag{8}$$

If $\phi > 0.5$, the firm prefers not to issue any debt at date 0, but if $\phi < 0.5$ then the firm prefers to issue debt and carry cash into the future. The firm is indifferent if $\phi = 0.5$. The intuition for this result is as follows. If $\phi > 0.5$, then the firm's investment opportunities tend to arrive mostly in state $H$. Since spare debt capacity increases investment in this state relative to investment in state $L$, it is optimal for the firm to maintain spare debt capacity; that is, to carry low debt and low cash into the future. The same intuition applies for the case in which $\phi < 0.5$. If valuable investments tend to arrive mostly in state $L$, then it is optimal for the firm to carry more cash.[8]

We note that the relative optimality of cash stocks versus spare debt capacity does not depend on the probability of the good and bad states. It might seem from casual examination of Eqs. (2) and (7) that the firm would prefer spare debt capacity when the probability of the good state (denote it by $p$) is high. However, an increase in $p$ also increases the market value of debt (see Eq. (4)). And this increases the amount of cash that the firm can carry into the future by issuing debt at date 0, which in turn increases future investment levels. The net effect is such that the difference between (2) and (7) becomes invariant to changes in $p$, for all $p < 1$.

As we show in detail in the general model below, our theory also delivers comparative statics for changes in the availability of initial internal funds ($c_0$). If $\phi$ is such that the firm prefers cash to debt capacity, then increases in the availability of internal funds (proxied, e.g., by higher cash flows) should result in higher cash balances, but it should *not* lead to lower debt issuance. To wit, in that case, the firm would benefit mostly from increasing investment in state $L$, while a reduction in current debt issuance would shift resources to state $H$. In contrast, if the firm prefers to keep spare debt capacity (has a high $\phi$), then an increase in current cash flows should result in reduced debt levels, but *not* in higher cash. For simplicity, the firm in the example starts with a zero existing debt level, so it cannot reduce current debt any further. However, if the level of existing debt is positive (which we handle in the general model), then higher current cash flows generally result in lower debt levels when $\phi$ is high.

## 3. The model

We made several simplifying assumptions in the example of Section 2. We now relax those assumptions and develop a full-blown model of the interplay between cash and debt policies.

First, in the example, we implicitly assumed that state $L$ was a default state. In the general model, state $L$ is simply a state in which the market value of the firm's debt goes down, as future cash flows are lower in expectation. Second, we assumed that the firm was originally all equity financed. In the general model, we allow for pre-existing debt. Third, we assumed that the date-1 production function was linear, and thus except for an extreme case in which $\tau = 1$, the firm was always constrained. In the general model, we allow for decreasing returns to scale and compare constrained and unconstrained solutions. Fourth, we assumed that date-0 debt was backed only by cash flows from assets that already exist at date 0. As a result, date-0 creditors could not access cash flows from the new investment opportunity at date 1. In the general model, we consider the more realistic case in which existing debt is backed by all pledgeable cash flows produced by the firm.

### 3.1. Structure

#### 3.1.1. Assets and technologies

The time line of the general model is presented in Fig. 2. The model has three dates. The firm starts at date 0 with assets in place that will produce random cash flows at date 2. We assume that the cash flow $c_2$ is produced entirely by assets that are already in place at date 0. At date 1,

[8] In fact, in this case the optimal financial policy is to carry as much cash as possible. In the example, this implies a face value of debt larger than 104 and investment levels $I_L = I_H = 117.86$.

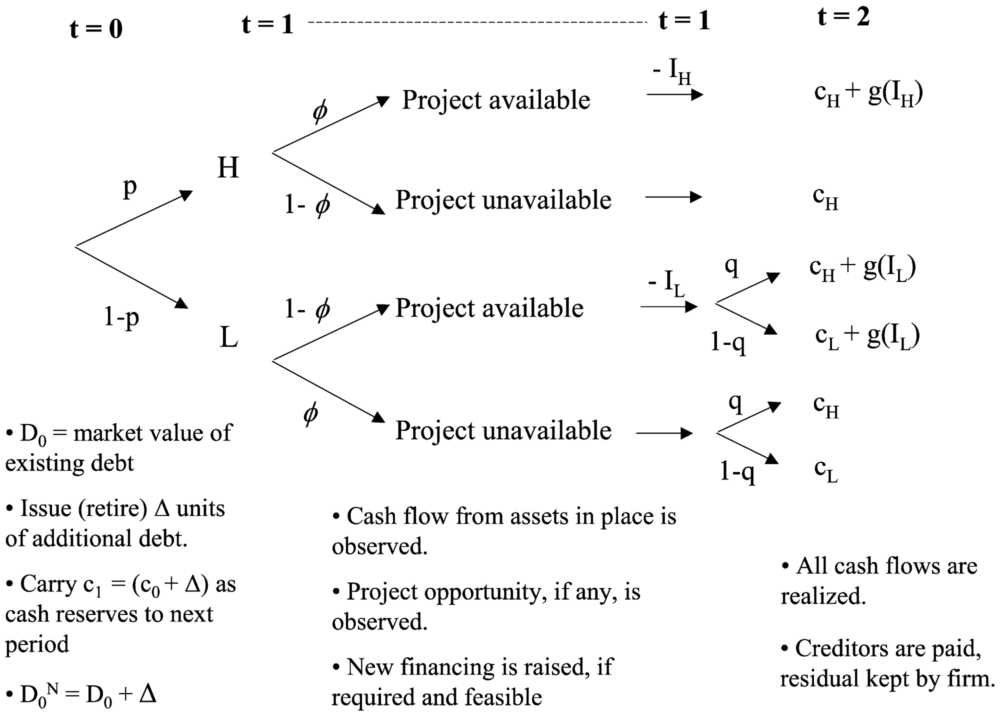


Fig. 2. Timeline for the general model.

the firm learns additional information regarding $c_2$. With probability $p$, the firm gets a positive signal about $c_2$ (state $H$). In this case, the firm learns that the cash flow will be high ($c_H$). With probability $(1-p)$, the firm gets a negative signal (state $L$). In state $L$, there is some residual uncertainty regarding cash flows. With probability $q \in (0,1)$, $c_2$ equals $c_H$, and with probability $(1-q)$, $c_2$ equals $c_L < c_H$. We let $\bar{c} = [qc_H + (1-q)c_L]$ denote the expected cash flow in state $L$. The probability that the date-2 cash flow is equal to $c_H$ is thus $[p + (1-p)q] \equiv p^*$.

The firm also has an existing amount of internal funds at date 0, equal to $c_0 > 0$. As in Section 2, we assume that this date-0 cash flow is in excess of any expenditure requirements at date 0 (such as date-0 investments). Accordingly, the cash flow $c_0$ can only be allocated to cash and (lower) debt balances. In particular, as we show in Section 3.2.2.1, the firm's net leverage is always fixed at the level determined by the endowments of cash and debt.[9]

Finally, the firm has a future investment opportunity that will be available at date 1. At that date, the firm can make an additional investment $I$, which produces output equal to $g(I)$ at date 2. The arrival of future growth opportunities is associated with the distribution of cash flows in the following way. In state $H$, the firm has an investment opportunity with probability $\phi < 1$, while with probability $(1-\phi)$ there is no investment opportunity. In state $L$, the probability

[9] All else fixed, higher date-0 investment requires the firm to increase its *net* leverage by issuing more debt or holding less cash. Although this mechanism could be important, we stress that our focus is on how the firm can transfer resources across future states of the world by choosing different *gross* levels of cash and debt. Interested readers can find an analysis of the case with date-0 investment in an unabridged version of the paper. In particular, we note that the implications that we derive in the present model are robust to the introduction of date-0 investments.

that the firm has an investment opportunity is equal to $(1-\phi)$, while with probability $\phi$ there is no investment opportunity. As in the example, the parameter $\phi$ captures the correlation between cash flows from existing assets and future investment opportunities.

The risk-free rate is normalized to zero, agents are risk-neutral, and all new financing is assumed to be fairly priced. To simplify the analysis, we take that the uncertainty about date 2 cash flows in state $L$ is only resolved at date 2. And we also assume that, conditional on being in state $L$, the realization of the investment opportunity is uncorrelated with the date 2 realization of cash flows from assets in place.

#### *3.1.2. Financing and limited pledgeability*

The firm starts the model at date 0 with an exogenous amount of debt of face value $d_2$, which is due at date 2. This level of debt is backed by cash flows from existing assets ($c_2$), cash flows produced by the new investment opportunity ($g(I)$), and cash reserves that the firm chooses to carry from date 0 into the future. At date 0, the firm can change the amount of debt that it carries into future periods by issuing additional claims against future cash flows (as in the example above), or by using current cash reserves to redeem some of its existing debt obligations. The amount of change in debt is captured by the parameter $\Delta$, which can be greater than zero (issuance of new debt) or smaller than zero (debt repurchase). After a debt issuance/repurchase initiative, the face value of debt changes to $d_2^N$, which is a function (to be determined) of $\Delta$ and $d_2$. The date-0 debt issuance directly increases the firm's date-1 cash balances, which is equal to $c_1 = c_0 + \Delta$.

At date 1, the firm can raise new financing backed by existing assets or by the new investment opportunity. We denote the amount of new financing at date 1 by $B_1$. The new financing is junior to the firm's existing debt claims; that is, date-1 debtholders only get paid after date-0 creditors have been made whole. Finally, we make the following assumptions concerning the pledgeability of the firm's cash flows and priority over cash reserves.

**Assumption I.** The firm can pledge to its creditors a fraction $\tau \in [0, 1)$ of the cash flows that both the existing assets and the new investment opportunity produce.

This limited pledgeability assumption is justified under various contracting frameworks. It arises, for example, from the inalienability of human capital (Hart and Moore, 1994). In short, entrepreneurs cannot contractually commit never to leave the firm. This leaves open the possibility that an entrepreneur will use the threat of withdrawing his human capital to renegotiate the agreed upon payments. If the entrepreneur's human capital is essential to the project, he will get a fraction of the cash flows. Limited pledgeability is also an implication of the Holmstrom and Tirole (1997) model of moral hazard in project choice. When project choice cannot be specified contractually, investors must leave a high enough fraction of the payoff to entrepreneurs so as to induce them to choose the project with highest potential profitability.

We stress here that what is crucial to the paper is that some firms in the economy are financially constrained. While understanding the precise source of financial constraints is of great importance to financial economists, it is less crucial to our results. We view the pledgeability fraction $\tau$ simply as a "metaphor" for agency problems such as moral hazard and adverse selection which limit the external financing ability of even publicly listed firms. The spirit of this assumption is similar to that in Holmstrom and Tirole (1998), who propose a tractable moral-hazard technology as a way of generating limited pledgeability of firms, and then analyze a rich set of questions relating to public and private provision of liquidity. Their specific moral-hazard technology, if interpreted literally, fits well only the entrepreneurial firms of the economy.

**Assumption II.** Creditors can seize at most a fraction $\tau^c \in [0, 1)$ of the firm's cash reserves. That is, the firm has priority over a fraction $(1 - \tau^c)$ of its cash reserves.

Unlike cash flows from new investment opportunities, in principle the firm's cash balances should be easily verifiable and contractible upon.[10] Thus, one might think that $\tau^c$ should always be equal to one. Nevertheless, it is generally *not optimal* to give creditors priority over cash reserves. In our model, the benefit of carrying cash balances is to enhance firm value by relaxing financial constraints in the future when valuable investment opportunities arise. If for some reason (for example, restrictive debt covenants) cash balances cannot be employed for future investments, then they cannot perform this value-enhancing role. Hence, it turns out that optimal contracting in our model sets $\tau^c$ to be zero, and never restricts the usage of cash by the firm for investments.[11] Intuitively, suppose that creditors have the highest priority over all cash balances. In particular, suppose that creditors can limit any use of cash for future investments. This would imply greater availability of cash for debt repayments, and, in turn, enable the firm to borrow more at date 0. However, this increased debt capacity creates no firm value in our model since it is equivalent to raising more financing, carrying it as cash balances, and merely paying cash balances back to creditors.

In practice, optimal contracting may not involve such complete flexibility in usage of cash balances by the firm because of free cash flow problems à la Jensen (1986). An additional consideration is that our model assumes that the firm does not have an investment opportunity available at date 0. In an alternative framework where the firm makes investment decisions jointly with cash and debt choices at date 0, optimal contracting may involve setting $\tau^c$ to be greater than zero, that is, allowing creditors at least some priority relative to the firm over cash balances. The benefit of increasing $\tau^c$ is that it allows the firm to raise more financing and thus invest more at date 0. However, in general it will not be optimal to increase $\tau^c$ all the way up to one, because of the negative impact on future investment. Thus, in a general set up we should expect $\tau^c$ to lie between 0 and 1.

We capture the considerations above in our reduced-form model by letting $\tau^c$ lie between 0 and 1. We note that our results hold qualitatively as long as $\tau^c$ is below one, or in other words, as long as the firm has at least *some* priority in employing cash balances towards value-enhancing investments. Finally, for parsimony of notation, we assume that the seizable fraction $\tau^c$ of cash balances, and the pledgeable fraction $\tau$ of cash flows from investments are equal; that is, $\tau^c = \tau < 1$. The specific values of $\tau^c$ and $\tau$ do not play a critical role in the derivation of our testable empirical implications.

If $d_2^N$ is such that there is remaining debt capacity from existing assets, then the firm may raise additional external funds. The firm can also raise external funds at date 1 by pledging the cash flows $g(I)$. However, limited pledgeability implies that the new financing that can be raised, $B_1$, is capped:

$$B_1^H \leqslant \left[\tau g(I_H) + \tau(c_1 + c_H) - d_2^N\right]^+, \quad \text{and}$$

[10] Nevertheless, see Myers and Rajan (1998) for a discussion of why liquid assets might in fact be less pledgeable than illiquid ones.

[11] A formal proof of this result is available upon request.

$$B_1^L \leqslant q\left[\tau g(I_L) + \tau(c_1 + c_H) - d_2^N\right]^+ + (1-q)\left[\tau g(I_L) + \tau(c_1 + c_L) - d_2^N\right]^+. \tag{9}$$

These expressions incorporate the uncertainty about cash flows from existing assets in state $L$. They also incorporate the natural condition that existing debt ($d_2^N$) is senior to the new financing raised at date 1. Finally, note that $B_1^H \geqslant B_1^L$.

### 3.2. Solution

We solve the model backwards starting at date 1. At this date, the firm chooses optimal investment and new financing levels for given amounts of cash and debt. Then, given expected future investment choices, the firm chooses the optimal cash and debt policies at date 0.

#### 3.2.1. Date-1 investment choice

In states with no investment opportunity the firm has no relevant choice to make. In states with investment opportunities the optimal date 1 behavior amounts to determining the value-maximizing investment levels, subject to the relevant budget and financing constraints.[12] Specifically, the firm solves the following program at each relevant state of nature given $\Delta$, $d_2^N$, and the realization of $c_2$:

$$\max_{I_s} g(I_s) - I_s \tag{10}$$

$$\text{s.t.} \quad I_s \leqslant (1-\tau)c_1 + B_1^s, \tag{11}$$

where $s = L, H$, and $B_1^s$ is given in each state by Eq. (9).

The financing available to the firm consists of (i) $(1-\tau)c_1$, the cash holdings of the firm that creditors do not have priority over, and (ii) $B_1$, the new financing that can be raised at date 1. We define $I^{FB}$, the first-best investment level, as

$$g'\left(I^{FB}\right) = 1. \tag{12}$$

If the financial constraint (11) is satisfied at $I^{FB}$, the firm invests $I^{FB}$. Note that $I^{FB}$ is state-independent. If that constraint is not satisfied at $I^{FB}$, then the firm invests the value that exactly satisfies (11). In the latter case, we have $g'(I_s) > 1$.[13] We shall denote this constrained investment level as $I_L(\Delta)$ for state $L$ and as $I_H(\Delta)$ for state $H$, where we emphasize the dependence on $\Delta$. These investment levels can be used to characterize the firm's financial constraints:

**Definition.** A firm is financially constrained if investment is below the first-best level in state $L$. A firm is financially unconstrained when investment is at the first-best level in both states.

Because $B_1^L \leqslant B_1^H$ for all $\Delta$, then $I_L \leqslant I_H$. Consequently, the firm will be unconstrained if there exists a choice of $\Delta$ that renders the firm unconstrained in state $L$. By construction, the firm will be unconstrained in state $H$ as well. We will use this observation to prove Proposition 1 below.

[12] In particular, the assumption of value-maximizing investment rules out the possibility of agency conflicts between debtholders and managers (e.g., debt overhang). Essentially, debt overhang would create an additional cost of carrying debt into date 1, and would push the firm towards a lower debt/lower cash policy. See Julio (2007) for a theoretical and empirical analysis of cash and debt policies in the presence of debt overhang.

[13] A necessary condition for the problem to be reasonable is that a reduction in investment relaxes the constraint, that is, $\tau g'(I_s) < 1$ for any $I_s$ that is less than $I^{FB}$. Otherwise, it would be possible for the firm to relax financial constraints simply by increasing investment.

### *3.2.2. Date-*0 *cash and debt policies*

We now determine the optimal date-0 financial policy, which can be subsumed in the choice of $\Delta$.

*3.2.2.1. Market values of debt* The first step is to determine how debt issuance, $\Delta$, affects the face value of debt, $d_2^N$. We make the following assumption about the existing level of debt:

$$\tau\big(c_0 + c_L + g\big(I^{FB}\big)\big) \leqslant d_2 \leqslant \tau(c_0 + c_H). \tag{13}$$

We make this assumption to limit the set of cases that we have to analyze to those that are of practical relevance. The upper bound in (13) implies that in state $H$ the firm's debt is riskless, even when there is no investment opportunity. The lower bound implies that if state $L$ is realized at date 1, then debt is risky even if an investment opportunity arises. With probability $q$ the debt will be paid fully, and with remaining probability $(1 - q)$ the debt will be in default. This uncertainty gets resolved only at date 2. Viewed from date-0 standpoint, the likelihood of no default on the firm's debt is given by $p^* = [p + (1 - p)q]$. In particular, notice that state $L$ is not a default state.

The market value of existing debt at date 0 is equal to

$$D_0 = p^* d_2 + (1 - p^*)\tau\big[c_0 + c_L + (1 - \phi)g\big(I_L(0)\big)\big], \tag{14}$$

where $I_L(0)$ is the investment level that obtains in state $L$ if $\Delta = 0$. From the perspective of date 0, this investment opportunity arises in state $L$ with probability $(1 - \phi)$.

If the firm wants to increase its existing debt (that is, to make $d_2^N > d_2$) so as to boost cash reserves, it must issue additional debt of an appropriate market value $\Delta$ at competitive prices in the credit market. Similarly, if it wants to reduce its debt (negative $\Delta$), it must repurchase debt at competitive prices. In other words, the new face value of debt $d_2^N(\Delta)$ must be such that

$$D_0^N = D_0 + \Delta. \tag{15}$$

Notice that this implies that the firm's net leverage is always fixed at $D_0^N - c_1 = D_0 - c_0$. It is natural to set $D_0 - c_0 > 0$, which implies that the minimum value $\Delta$ can take is equal to $\Delta_{\min} = -c_0$. In other words, the maximum debt redemption at date 0 is limited by the amount of cash balances available to the firm at that date.

Given competitive debt pricing, we can write down an expression for $D_0^N$ as a function of future debt repayments in each of the date-2 states that arise:

$$\begin{aligned} D_0^N = {} & p\big[\phi \min\big[\tau\big[c_1 + c_H + g\big(I_H(\Delta)\big)\big], d_2^N\big] + (1 - \phi)\min\big[\tau(c_1 + c_H), d_2^N\big]\big] \\ & + (1 - p)q\big[\phi \min\big[\tau(c_1 + c_H), d_2^N\big] + (1 - \phi)\min\big[\tau\big[c_1 + c_H + g\big(I_L(\Delta)\big)\big], d_2^N\big]\big] \\ & + (1 - p^*)\big[\phi \min\big[\tau(c_1 + c_L), d_2^N\big] + (1 - \phi)\min\big[\tau\big[c_1 + c_L + g\big(I_L(\Delta)\big)\big], d_2^N\big]\big]. \end{aligned} \tag{16}$$

To understand this expression, consider Fig. 2. There are six potentially distinct states in date 2, and for each of these states we must determine whether the face value $d_2^N$ will be fully repaid. The states differ with respect to realizations of cash flow from existing assets and with respect to whether there are pledgeable cash flows from new investments.

In order to simplify the expression in Eq. (16), we can limit the range of values that $d_2^N$ can take. Specifically, we assume that debt must remain riskless in state $H$, even after additional issuance:

$$d_2^N \leqslant d_2^{\max} = \tau(c_1 + c_H). \tag{17}$$

We show in Appendix A that Eqs. (13) to (17) imply the following relation between $d_2^N$ and $\Delta$:

$$\begin{aligned} d_2^N(\Delta) &= D_0 + \Delta, \text{ if } d_2^N \leqslant \tau(c_1 + c_L), \\ &= \frac{[1-(1-p^*)\phi\tau]\Delta}{[1-(1-p^*)\phi]} + k_1, \text{ if } \tau(c_1 + c_L) < d_2^N \leqslant \tau\big(c_1 + c_L + g\big(I_L(\Delta)\big), \\ &= \frac{[1-(1-p^*)\tau]\Delta - (1-p^*)\tau(1-\phi)g\big(I_L(\Delta)\big)}{p^*} + k_2, \\ &\quad \text{if } \tau\big(c_1 + c_L + g\big(I_L(\Delta)\big) < d_2^N \leqslant d_2^{\max}, \end{aligned} \tag{18}$$

where $k_1$ and $k_2$ are functions that do not depend on $\Delta$. Equation (18) gives the new face value of debt for $\Delta > 0$ (i.e., when the firm issues additional debt) and also for $\Delta < 0$ (i.e., when the firm prefers to repurchase debt). We also show in Appendix A that $\frac{\partial d_2^N}{\partial \Delta} \geqslant 1$ (see proof of Lemma 1). Because $d_2^N(\Delta)$ is a monotonic function, Eq. (17) implies that the maximum value of $\Delta$ is such that $d_2^N(\Delta_{\max}) = d_2^{\max}$.

For future reference we define two cutoff values for $\Delta$, namely $\widetilde{\Delta}$ and $\overline{\Delta}$. $\widetilde{\Delta}$ is defined by:

$$d_2^N\big(\widetilde{\Delta}\big) = \tau\big(c_0 + \widetilde{\Delta} + c_L + g\big(I_L\big(\widetilde{\Delta}\big)\big)\big). \tag{19}$$

Thus, $\widetilde{\Delta} < \Delta_{\max}$ is such that for all $\Delta > \widetilde{\Delta}$ debt is risky in state $L$. Finally, $\overline{\Delta}$ is defined by:

$$\tau\big(c_0 + \overline{\Delta} + c_L\big) = d_2^N\big(\overline{\Delta}\big), \tag{20}$$

and is such that for $\Delta < \overline{\Delta} < \widetilde{\Delta}$ debt is riskless in state $L$. If $\overline{\Delta} < \Delta < \widetilde{\Delta}$, then debt is risky in state $L$, but only if no investment opportunity arises.

*3.2.2.2. Optimal policies* The optimal choice of $\Delta$ is determined by the following program:

$$\max_{\Delta\in[\Delta_{\min}\Delta_{\max}]} p\phi\big[g\big(I_H^*(\Delta)\big) - I_H^*(\Delta)\big] + (1-p)(1-\phi)\big[g\big(I_L^*(\Delta)\big) - I_L^*(\Delta)\big], \tag{21}$$

where $I_H^*(\Delta)$ and $I_L^*(\Delta)$ are the investment levels that obtain for each choice of $\Delta$. Specifically, if $\Delta$ is such that the first-best investment level is feasible for a given state $s$, then $I_s^*(\Delta) = I^{FB}$. Otherwise, $I_s^*(\Delta)$ is equal to $I_s(\Delta)$ as determined by the financial constraint, Eq. (11).

Before we characterize the optimal solution, it is useful to understand intuitively what is accomplished by the choice of financial policy. The key intuition is established by the following lemma.

**Lemma 1.** *For $\Delta \in (\widetilde{\Delta}, \Delta_{\max}]$, $I_H(\Delta)$ is strictly decreasing in $\Delta$, and $I_L(\Delta)$ is strictly increasing in $\Delta$.*

In words, debt issuance at date 0 is associated with a tradeoff in the future choice of investment when debt is risky ($\Delta > \widetilde{\Delta}$). In particular, if a firm chooses to issue additional debt (increase $\Delta$), it can increase investment in the state of nature in which cash flows are low (state $L$) by increasing its cash reserves. However, this decreases feasible investment in state $H$. The intuition for this result is the same as the one established in the example of Section 2. Because debt value goes down in state $L$, the date-0 value of debt is supported mostly by state-$H$ cash flows. Thus, an increase in $\Delta$ (higher current debt issuance) transfers resources from future high cash flow states into the present. By holding cash, the firm can then transfer these resources into future low cash flow states.[14]

Lemma 1 shows that the firm's ability to hedge using cash and debt relies on the fact that the expected payoff to debtholders (the value of debt) correlates positively with firm cash flows. In the model, this is captured by the fact that debt is riskless in state $H$, but becomes risky in state $L$. Investors who hold risky debt receive future payments that are contingent on the realization of firm cash flows. In exchange for this risky claim investors provide funds to the firm, which can be held in riskless instruments such as savings accounts and money market funds. In this sense, holders of risky debt can absorb some of the volatility in firm cash flows. Importantly, notice that the model does not rely on the assumption that state $L$ is a default state. All that is required is that the probability of future default increases in state $L$ relative to state $H$.

An alternative way to understand this result is as follows. We show in Appendix A that if debt is risky, then the effects of $\Delta$ on cash balances and on the face value of debt are given by:

$$\frac{\partial c_1}{\partial \Delta} = 1 < \frac{\partial d_2^N}{\partial \Delta}. \tag{22}$$

Increasing debt issuance by one dollar increases cash balances by the same amount, but increases the face value of debt $d_2^N$ by more than one dollar. The firm can save the additional dollar of cash, but in state $H$ date-0 creditors will capture the full face value (which increased by more than one dollar). Conversely, the value of debt conditional on state $L$ increases by less than one dollar (debt becomes risky if state $L$ is realized). Thus, date-0 creditors will capture less than a dollar if state $L$ occurs. The additional dollar of cash savings will decrease feasible investment in state $H$, but will allow for higher investment in state $L$.

Equation (22) and Lemma 1 hold for any $\tau^c$ (the fraction of cash reserves that creditors have priority over) lower than one. If $\tau^c$ equals one, then the firm's cash balances effectively belong to creditors. In particular, if $\tau^c = 1$ the firm does not need to increase $d_2^N$ by more than one dollar in order to hold an additional dollar of cash. In this case, we would have $\frac{\partial d_2^N}{\partial \Delta} = 1$. However, as we discussed in Section 3.1.2, setting $\tau^c$ equal to 1 is not optimal because it reduces the value of cash balances.

We use the properties of $I_H(\Delta)$ and $I_L(\Delta)$ to define two additional cutoff values for $\Delta$. Given that $I_L(\Delta)$ is increasing in $\Delta$, we can define a cutoff level $\Delta_{\text{unc}}^L$ such that for all $\Delta < \Delta_{\text{unc}}^L$ the firm is financially constrained in state $L$. Similarly, since $I_H(\Delta)$ is decreasing in $\Delta$, we can define $\Delta_{\text{unc}}^H$ such that for $\Delta \leqslant \Delta_{\text{unc}}^H$, the firm becomes unconstrained in state $H$. We can now state and prove the central result of our theory.

**Proposition 1.** *The optimal financial policy of the firm depends on financial constraints and on the correlation between cash flows and investment opportunities as follows*:

- *If the firm is financially unconstrained, it is indifferent between all possible $\Delta$ in the range $[\widehat{\Delta}, \Delta_{\max}]$ where $\widehat{\Delta} = \max(\Delta_{\min}, \Delta_{\text{unc}}^L)$. Any value of $\Delta < \widehat{\Delta}$, if feasible, yields a lower value for the firm*;

[14] Note that $\Delta > \widetilde{\Delta}$ implies that state-$L$ debt is risky even if an investment opportunity arises. In particular, if $\overline{\Delta} < \Delta < \widetilde{\Delta}$, then debt is riskless in states with investment opportunities, and thus while holding cash transfers resources to state $L$, it does not increase state-$L$ investment.

- *If the firm is financially constrained, the optimal financial policy depends on the parameter $\phi$. In particular, there exist two threshold levels $\bar{\phi}$ and $\bar{\bar{\phi}}$, satisfying $0 < \bar{\phi} < \bar{\bar{\phi}} < 1$, such that*
  - *For $\phi \leqslant \bar{\phi}$, the optimal policy is to choose $\Delta$ as high as possible*; *that is, $\Delta^* = \Delta_{\max} \geqslant 0$.*
  - *For $\phi \geqslant \bar{\bar{\phi}}$, the optimal policy is to choose $\Delta$ as low as possible, conditional on the firm being unconstrained in state $H$; that is, $\Delta^* = \max(\Delta_{\min}, \Delta^H_{\text{unc}})$.*
  - *For $\bar{\phi} < \phi < \bar{\bar{\phi}}$, the optimal policy is to choose an interior level of $\Delta$. In addition, $\frac{\partial \Delta^*}{\partial \phi} < 0$ in this range.*

In words, the first part of Proposition 1 suggests that unconstrained firms should be indifferent between all possible choices of $\Delta$ that ensure that the firm will remain unconstrained. In contrast, constrained firms' optimal financial policy will depend crucially on the correlation between cash flows from assets and new investment opportunities. Essentially, if this correlation is low enough ($\phi \leqslant \bar{\phi}$), then the optimal policy is to increase investment in state $L$ as much as possible. This is accomplished by issuing the maximum amount of debt, that is, making $\Delta$ equal to the highest possible value ($\Delta_{\max}$), and carrying higher cash balances into the future. On the other hand, if the correlation is higher ($\phi > \bar{\phi}$), then it becomes optimal to make $I_H > I_L$, which requires leaving some spare debt capacity for the future ($\Delta^* < \Delta_{\max}$). Finally, for very high correlation values ($\phi > \bar{\bar{\phi}}$) it becomes optimal to shift investment into state $H$ as much as possible, which involves using current internal funds to reduce debt until either the firm exhausts its internal funds ($\Delta^* = \Delta_{\min}$), or until the firm becomes unconstrained in state $H$ ($\Delta^* = \max(\Delta_{\min}, \Delta^H_{\text{unc}})$). These effects are depicted in Fig. 3.

The intuition behind these results of this section is similar to that discussed in the example of Section 2. If $\phi$ is high, investment opportunities tend to arrive in states with high cash flows. In this case, the firm maximizes the value of future investments by increasing financing capacity in state $H$. As Lemma 1 shows, this is accomplished by making $\Delta$ small (not issuing, and possibly retiring debt). Conversely, if $\phi$ is low, the firm benefits from increasing financing capacity in

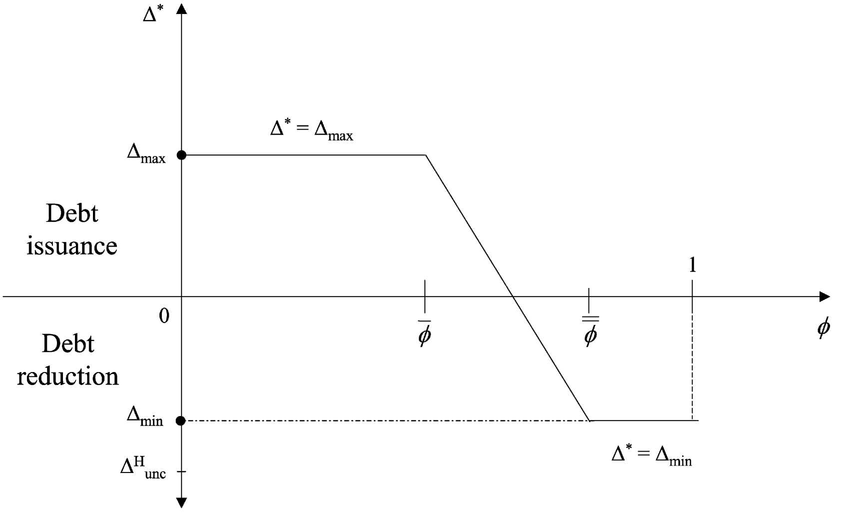


Fig. 3. Optimal financial policy of a constrained firm (Proposition 1).

state $L$, which involves holding high cash balances, and possibly issuing additional debt to boost cash reserves.

In the model, the firm hedges by committing to repay a large amount to date-0 debtholders in state $H$, and then transferring cash balances to state $L$. One might then wonder whether this hedging policy is robust to the possibility that the date-0 debt claim might be renegotiated downwards once the firm reaches state $H$. Given the assumption of value-maximizing investment at date 1 (see footnote 12), date-1 renegotiation can be optimal only if it relaxes firm's date-1 financing constraint. However, date-0 debtholders will not agree to a reduction of the date-0 claim unless they receive a date-1 claim of equal value. Such an exchange of claims will leave firm's date-1 financing capacity unchanged, since it must produce a corresponding reduction in the amount that the firm can raise from date-1 creditors ($B_1^H$). Therefore, renegotiation cannot increase firm's date-1 financing capacity, and will generally not arise in equilibrium.

In order to generate comparative statics that lend themselves to empirical testing, we focus on the impact of variations in the firm's availability of internal funds ($c_0$ in the model). We present and discuss these comparative statics in turn.

**Proposition 2.** *Suppose that at the optimal solution $\Delta^*$, the firm is financially constrained in both future states. We obtain the following effects on the firm's cash and debt policies from a variation in the availability of internal funds, $c_0$:*

- *If the correlation between cash flows and investment opportunities is low ($\phi < \bar{\phi}$), then we have $\frac{\partial c_1}{\partial c_0} > 0$, and $\frac{\partial \Delta^*}{\partial c_0} > 0$.*
- *If the correlation between cash flows and investment opportunities is high ($\phi > \bar{\bar{\phi}}$), then we have $\frac{\partial c_1}{\partial c_0} = 0$, and $\frac{\partial \Delta^*}{\partial c_0} < 0$.*

These comparative statics follow directly from the optimal policies characterized in Proposition 1. If the correlation $\phi$ is low, then the firm's optimal policy involves issuing debt against future cash flows and hoarding cash. Thus, additional inflows of cash will be primarily allocated into cash balances. Because creditors have priority over a fraction of cash balances, and because cash flows from new investment opportunities are pledgeable, debt capacity increases and the firm can increase debt as well. Accordingly, both cash and debt should respond positively to increases in cash flow. In contrast, if $\phi$ is high, the firm's optimal policy consists of saving debt capacity for future periods, and holding little cash. In this case, higher cash flows are primarily used to reduce outstanding debt.[15]

### *3.3. Empirical implications*

Our theory's key empirical implications concern how constrained firms should allocate cash flows into cash and debt balances. As we have emphasized, this dimension of financial policy

[15] For intermediate correlation levels ($\phi \in (\bar{\phi}, \bar{\bar{\phi}})$), the firm is in an equilibrium in which internal funds are split between debt issues/repayments and cash balances (cf. Proposition 1). In this range, intuition would suggest that an increase in cash flows would lead *both* to an increase in cash ($\frac{\partial c_1}{\partial c_0} > 0$) and a reduction in debt issuance ($\frac{\partial \Delta}{\partial c_0} < 0$). Nevertheless, the precise change in financial policies depends also on the rate of change in marginal productivities following a change in cash flows—the comparative statics are less clear in this range. Proposition 2 focuses on correlation ranges for which implications are clear-cut.

is governed by a hedging motive, which is captured by the correlation between cash flows and investment opportunities under constrained financing. Our first two implications are derived directly from Proposition 2:

**Implication 1.** If the correlation between cash flows and investment opportunities is low (the firm has high hedging needs), then constrained firms should allocate their free operating cash flows primarily towards cash balances. These firms' cash flow sensitivity of cash, defined as the fraction of excess cash flow allocated to cash holdings, should be positive. In addition, their cash flow sensitivity of debt, defined as the effect of cash flows on outstanding debt, should also be positive.

**Implication 2.** If the correlation between cash flows and investment opportunities is high (low hedging needs), then constrained firms should display no propensity to save cash, and a strong propensity to use current cash flows to reduce debt. These firms' cash flow sensitivity of cash should be insignificantly different from zero and their cash flow sensitivity of debt should be negative.

A relevant observation is that the prediction that the cash flow sensitivity of debt should be negative for some constrained firms does not imply that such firms must always *redeem* debt. In the model of Section 3 the firm has no use for cash at date 0, and thus when it does not benefit from carrying cash it simply uses cash flows to retire debt. More generally, however, the firm may have required expenditures at date 0. Implication 2 should be interpreted as saying that constrained firms with low hedging needs carry less debt into the future when they experience positive cash flows innovations. In other words, on net terms, the firm may or may not display positive debt issuance activities, yet those activities should *fall* in response to positive cash flow shocks.

Finally, we note that the strict indeterminacy of financial policies for unconstrained firms in our model only holds in the absence of other costs and benefits of cash and debt. In the presence of an additional cost of carrying cash (such as a low yield), unconstrained firms may prefer to use excess cash flows to reduce debt instead of adding more cash to their balance sheets. Likewise, in the presence of an additional benefit of holding cash (or a benefit to carrying debt), unconstrained firms may prefer saving cash as opposed to reducing debt. Importantly, notice that because unconstrained firms do not worry about future financing capacity, their cash and debt policies lack a hedging motive. In practical terms, this implies that irrespective of the *levels* of the cash flow sensitivities of cash and debt one might observe for unconstrained firms, these sensitivities should *not depend* on the correlation between cash flows and investment opportunities. This insight provides us with a way to identify our model irrespective of the average levels of cash flow sensitivities that we observe for constrained and unconstrained firms. We summarize these considerations in an additional testable implication.

**Implication 3.** The levels of unconstrained firms' cash flow sensitivities of cash and debt may differ from zero if there are additional unmodeled costs or benefits of cash and debt. However, these sensitivities should be independent of the correlation between cash flows and investment opportunities.

## 4. Empirical tests

### 4.1. Sample selection criteria

To test our model's predictions we use a sample of manufacturing firms (SICs 200–399) taken from COMPUSTAT's P/S/T, Full Coverage, and Research annual tapes over the 1971–2001 period. We require firms to provide valid information on their total assets, sales, debt, market capitalization, cash holdings, operating income, depreciation, tax payments, interest payments, and dividend payments. We deflate all series to 1971 dollars.

Our data selection criteria and variable construction approach follows that of Almeida et al. (2004), who study the impact of financing constraints on the management of internal funds, and that of Frank and Goyal (2003), who look at external financing decisions. Similarly to Frank and Goyal (2003), we look at changes in debt and cash positions using data from firms' *flow of funds statements* (available from 1971 onwards). As in Almeida et al. (2004), we discard from the raw data those firm-years for which the market capitalization is less than \$10 million as well as firm-years displaying asset or sales growth exceeding 100%. The first screen eliminates from the sample those firms with severely limited access to the public markets—our theory about the internal–external funding interplay implies that the firm has active (albeit potentially constrained) access to funds from the capital markets. The second screen eliminates those firm-years registering large jumps in business fundamentals (typically indicative of major corporate events).

To identify firms with active cash and debt policies, we further require firms to have at least \$0.5 million in cash in their balance sheets, and that they register positive debt in at least one year of the sample period. We also require that firm annual sales exceed \$1 million, and we eliminate firm-years for which debt exceeds total assets (nearly-bankrupt firms). Cash and debt policies of firms that are near bankruptcy are generally very different from those of other firms (see, e.g., Acharya et al., 2000, 2006).

Finally, we eliminate those firms whose market-to-book asset ratio (or $Q$) is either negative or greater than 10 (see Gilchrist and Himmelberg, 1995 and Almeida and Campello, 2007). Also following Gilchrist and Himmelberg (1995) and Almeida and Campello (2007), we try to minimize the impact of sample attrition on the stability of the data process by requiring that firms provide six consecutive years of valid information on their debt and cash policies. Requiring firms to appear for a minimum of periods in the sample serves another important objective: it allows us to compute a robust empirical counterpart of the notion of firms' "hedging needs" (more on this shortly). Our final sample consists of 20,146 firm-year observations. Descriptive statistics for the key empirical variables we construct using this sample are provided below.

### 4.2. Testing methodology

To test our theory, we need to specify an empirical model that allows us to gauge how cash flow innovations relate to cash savings and debt issuance policies. We also need to gage the extent to which firms in our data are likely to face financing constraints. Finally, we need an implementable empirical counterpart for the notion of hedging needs. We tackle each one of these issues in turn.

#### 4.2.1. Empirical specification

We examine the simultaneous, within-firm responses of cash and debt policies to cash flow innovations across sets of constrained and unconstrained firms through a system of equations.

The equations in the system are parsimoniously specified. In addition to firm size and variables that are needed to identify the system, the financial policy equations only include proxies that we believe are related to the primitives of our theory: cash flows and investment opportunities. Crucially, rather than taking marginal cash savings and debt issuance/repurchase decisions as orthogonal to each other, we fully endogenize debt and cash policies in our empirical estimations. In this way, the impact of cash flow on cash savings accounts for marginal, contemporaneous net debt issuance/repurchase decisions. The same goes for the impact of cash flows on marginal debt decisions—they, too, endogenize cash policies.[16]

Define $\Delta Debt$ as the ratio of the net long-term debt issuances (COMPUSTAT's item #111 − item #114) to total book value of assets (item #6), and $\Delta CashHold$ as changes in the holdings of cash and other liquid securities (item #234) divided by total assets. *CashFlow* is an empirical measure that is designed to proxy for free cash flow in our theory. Recall, we want to study a firm's use of "free" or "uncommitted" cash inflows towards its cash and debt balances. In empirically measuring these inflows, we start from the firm's gross operating income (COMPUSTAT's item #13) and from it subtract amounts committed to capital reinvestment (proxied by asset depreciation, item #14), to the payment of taxes (item #16), to the payment of debtholders (interest expense, item #15), and to payments to equity holders (dividends, items #19 and #21). We then scale the remainder by the book value of assets.[17] Our basic proxy for investment opportunities, $Q$, is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item # 25) − item #60 − item #74) / (item #6).

Throughout the analysis we discuss estimates returned from the following 3SLS system:

$$\begin{aligned}\Delta Debt_{i,t} = {} & \alpha_0 + \alpha_1 CashFlow_{i,t} + \alpha_2 Q_{i,t} + \alpha_3 Size_{i,t} \\ & + \alpha_4 \Delta CashHold_{i,t} + \alpha_5 Debt_{i,t-1} + \sum_i firm_i + \sum_t year_t + \varepsilon^d_{i,t},\end{aligned} \tag{23}$$

$$\begin{aligned}\Delta CashHold_{i,t} = {} & \beta_0 + \beta_1 CashFlow_{i,t} + \beta_2 Q_{i,t} + \beta_3 Size_{i,t} \\ & + \beta_4 \Delta Debt + \beta_5 CashHold_{i,t-1} + \sum_i firm_i + \sum_t year_t + \varepsilon^c_{i,t},\end{aligned} \tag{24}$$

[16] To see how spurious inferences could be drawn if cash and debt policies are not corrected for endogeneity, consider the case of a firm facing increased demand for investment (say, because it learns about the existence of positive NPV projects in its opportunity set). Depending on the underlying correlation between the firm's cash flows and investment opportunities (hedging needs), we could have the case in which the firm both issues debt and observes a high cash flow. Clearly, the mechanical ("pure accounting") effect of a debt issuance is to increase the firm's cash stocks, as the proceeds from security issuances are parked in the firm's cash accounts until capital is ultimately purchased. Under this scenario, it is easy to see that a regression of changes in cash reserves on cash flows alone will lead to the spurious conclusion that the firm is "saving cash out of cash flows." Likewise, when making inferences about the sensitivity of debt changes to cash flows, one would like to account for changes in the firm's cash stocks: one cannot determine if a firm reduces debt (as opposed to saving cash) in response to cash flow shocks unless we net out the effect of changes in cash balances from the association between debt and cash flows.

[17] As Almeida et al. (2004), we take depreciation (item #14) as an estimate of the minimum amount of investment that is needed to avoid capital depletion. In this vein, we see it as a proxy for "nondiscretionary" investment (observed investment spending is, of course, a more discretionary measure of investment). Dividends can be seen as discretionary; however, in practice firms do not seem to fine-tune their dividend policy according to their cash flow process (dividends are relatively sticky, whereas cash flows are not). We also experimented with the idea of computing *CashFlow* without the inclusion of dividends and our findings were qualitatively similar. The same happens if, following a number of studies in the capital structure literature, we compute *CashFlow* as net income before extraordinary items (COMPUSTAT's item #18).

where *Size* is the natural log of sales (item #12), and *firm* and *year* absorb firm- and time-specific effects, respectively. Our theory's central predictions concern the responses of debt issuance and cash savings to cash flows, captured by $\alpha_1$ and $\beta_1$ in Eqs. (23) and (24), respectively. Lagged *levels* (i.e., stocks) of the dependent variables in those equations are entered in order to identify the system.[18] Accordingly, *Debt* in Eq. (23) is defined as COMPUSTAT's item #9 over item #6, and *CashHold* in Eq. (24) is item #1 over item #6. We explicitly control for possible biases stemming from unobserved individual heterogeneity and time idiosyncrasies by expunging firm- and year-fixed effects from our estimates.[19] In fitting the data, we allow residuals to be correlated across the debt and cash models; that is, reported $t$-statistics are deflated to account for cross-equation residual correlation.

### 4.2.2. Financial constraints criteria

Testing the implications of our model requires separating firms according to measures of the financing frictions that they face. There are a number of plausible approaches to sorting firms into financially constrained and unconstrained categories, and we do not have strong priors about which approach is best. Following Gilchrist and Himmelberg (1995) and Almeida et al. (2004), we use a number of alternative (standard) schemes to partition our sample:

- Scheme #1: In every year over the 1971 to 2001 period, we rank firms based on their payout ratio and assign to the financially constrained (unconstrained) group those firms that are in the bottom (top) three deciles of the annual payout distribution. We compute the payout ratio as the ratio of total distributions (dividends and repurchases) to operating income. The intuition that financially constrained firms have significantly lower payout ratios follows from Fazzari et al. (1988), among many others, in the financial constraints literature. In the capital structure literature, Fama and French (2002) use payout ratios as a measure of the difficulties firms may face in assessing the financial markets.
- Scheme #2: We rank firms based on their asset size over the 1971 to 2001 period and assign to the financially constrained (unconstrained) group those firms that are in the bottom (top) three deciles of the size distribution. The rankings are again performed on an annual basis.[20] This approach resembles that of Erickson and Whited (2000), who also distinguish between groups of financially constrained and unconstrained firms on the basis of size. Fama and French (2002) and Frank and Goyal (2003) also associate firm size with the degree of external financing frictions. The argument for size as a good observable measure of financial constraints is that small firms are typically young, less well known, and thus more vulnerable to capital market imperfections.

[18] The rationale for our identification strategy is that current changes in the debt and cash balances should correlate with the initial stock of those accounts. In addition, those lagged stock values become redundant in the presence of the proxies they instrument for (e.g., $CashHold_{i,t-1}$ becomes redundant in Eq. (23) after the inclusion of $\Delta CashHold_{i,t}$). For robustness, we check that our results also hold when we use twice lagged levels of debt and cash as instruments.

[19] Modeling firm- and year-idiosyncratic effects on the regression error structure as either fixed (as we do) or random (via clustering techniques) yield similar results.

[20] Thus, in Schemes #1 and #2 firms are allowed to migrate across categories. Since regressions (Eqs. (23) and (24)) are estimated separately for constrained and unconstrained groups, a single firm $j$ might then appear in the regressions as two different firms, corresponding to the years in which it enters each group. We note, however, that the results are unchanged if we assign firms to constrained and unconstrained groups based on their average size and dividend policies for the entire time period. In practice, there are very few firms that actually change categories in the data.

- Scheme #3: We retrieve data on firms' bond ratings and categorize as being financially constrained those firms that never had their public debt rated during our sample period. Given that unconstrained firms may choose not to use debt financing and hence may not have a debt rating, we only assign to the constrained subsample those firm-years that *both* lack a rating and report positive debt (see Faulkender and Petersen, 2006).[21] Financially unconstrained firms are those whose bonds have been rated during the sample period. Related approaches for characterizing financial constraints are used by Whited (1992) and Lemmon and Zender (2004). The advantage of this measure over the former two is that it gages the *market*'s assessment of a firm's credit quality. The same rationale applies to the next measure.
- Scheme #4: We retrieve data on firms' commercial paper ratings and categorize as being financially constrained those firms that never display any ratings during our sample period. Observations from these firms are only assigned to the constrained subsample in the years a positive debt is reported. Firms whose commercial papers receive ratings during our sample period are considered unconstrained. This approach follows from the work of Calomiris et al. (1995) on the characteristics of commercial paper issuers.

Table 1 reports the number of firm-years under each of the eight financial constraint categories used in our analysis. According to the payout scheme, for example, there are 6153 financially constrained firm-years and 6231 financially unconstrained firm-years. The table also shows the extent to which the four classification schemes are related. For example, out of the

Table 1
Constraint type cross-correlations

| Financial constraints criteria | Payout policy | | Firm size | | Bond ratings | | CP ratings | |
|---|---|---|---|---|---|---|---|---|
| | (C) | (U) | (C) | (U) | (C) | (U) | (C) | (U) |
| 1. Payout policy | | | | | | | | |
| Constrained firms (C) | 6153 | | | | | | | |
| Unconstrained firms (U) | | 6231 | | | | | | |
| 2. Firm size | | | | | | | | |
| Constrained firms (C) | 2680 | 1221 | 6060 | | | | | |
| Unconstrained firms (U) | 1078 | 2645 | | 6231 | | | | |
| 3. Bond ratings | | | | | | | | |
| Constrained firms (C) | 2605 | 2190 | 4217 | 922 | 7953 | | | |
| Unconstrained firms (U) | 3548 | 4041 | 1843 | 5309 | | 12,193 | | |
| 4. Commercial paper ratings | | | | | | | | |
| Constrained firms (C) | 4920 | 3229 | 5763 | 1781 | 7689 | 5254 | 12,943 | |
| Unconstrained firms (U) | 1233 | 3002 | 297 | 4450 | 264 | 6939 | | 7203 |

This table displays constraint type cross-classifications for the four criteria used to categorize firm-years as either financially constrained or unconstrained (see text for full details). To ease visualization, we assign the letter (C) for constrained firms and (U) for unconstrained firms in each row/column. All data are from the annual COMPUSTAT industrial tapes and the sample period is 1971 through 2001.

21 Firms with no bond rating and no debt are considered unconstrained, but our results are not affected if we treat these firms as neither constrained nor unconstrained. We use the same criterion for firms with no commercial paper rating and no debt in Scheme #4. In unreported robustness checks, we have restricted the sample to the period where firms' bond ratings are observed every year (from 1986 to 2001), allowing firms to migrate across constraint categories. Our conclusions are insensitive to these changes in sampling window and firm assignment criteria.

6153 firm-years classified as constrained according to the payout scheme, 2680 are also constrained according to the size scheme, while a smaller number, 1078 firm-years, are classified as unconstrained. The remaining firm-years represent payout-constrained firms that are neither constrained nor unconstrained according to size. In general, there is a positive correlation among the four measures of financial constraints. For example, most small (large) firms lack (have) bond ratings. Also, most small (large) firms have low (high) payout policies. However, the table also makes it clear that these cross-group correlations are far from perfect. This raises the hurdle for finding robust evidence in support of our theory.

#### *4.2.3. Measuring hedging needs*

While the notion of "hedging needs" has been advanced in prior theoretical work (Froot et al., 1993), it has not been operationalized empirically. Like financial constraints, measuring hedging needs is not straightforward. In particular, to identify firms that have a high need for hedging, we need to examine the relation between firms' operating cash flows and a proxy for investment opportunities that is both exogenous to firms' cash flow process and extraneous to our baseline empirical model (Eqs. (23) and (24)). Note that we cannot look directly at the correlation between a firm's cash flows and investment spending, since the two are endogenously related when the firm is financially constrained. The same is true for the correlation between a firm's cash flows and its own $Q$ if the anticipation of a firm's ability to pursue profitable investment opportunities is already capitalized in its stock price. We consider two alternative measures of investment opportunities that fit the above requirements, both of them based on industry-level proxies. Providing these empirical counterparts to the theoretical notion of hedging needs, and demonstrating their usefulness in understanding the cash versus negative debt question is the foremost empirical contribution of our paper.

First, following a number of papers that link expenditures in R&D to growth opportunities (e.g., Graham, 2000 and Fama and French, 2002), we look at the correlation between a *firm*'s cash flow from current operations (*CashFlow*) and its *industry-level* median R&D expenditures to assess whether a firm's availability of internal funds is correlated with its demand for investment.[22] We compute this correlation, firm-by-firm, identifying a firm's industry based on its three-digit SIC code. We then partition our sample into firms displaying low and high correlation between investment demand and supply of internal funds. To be precise, recall that our theory has particularly clear implications for cash and debt policies of constrained firms at the high and low ends of the correlation between cash flows and investment opportunities. Accordingly, we assign to the group of "low hedging needs" those firms for which the empirical correlation between cash flow and industry R&D is above 0.2, and to the group of "high hedging needs" those firms for which this correlation is below $-0.2$. We note that although these cutoffs may seem arbitrary they help ensure that firms in either group have correlation coefficient estimates that are statistically reliable (either positive or negative).[23] We also stress that our results are robust

[22] R&D expenditures are measured as COMPUSTAT item #46 divided by item #6. Notice that all of the firms in our sample come from the manufacturing sector. Industries in this sector of the economy are relatively homogeneous in a number of dimensions. We think of temporal, cross-industry differences in R&D expenditures as a phenomenon that is correlated with the emergence of differential growth opportunities across manufacturing industries (caused, for example, by changes in consumer preferences and technological innovations).

[23] This point is important in that our panel sample, although large in the cross-section dimension, is relatively limited in the time series dimension (this is the dimension used to compute the correlation between firm-level cash flows and industry-level investment opportunities).

to changes in these cutoffs. For instance, our conclusions also hold if we use ±0.3 cutoffs, with the natural caveat that our subsamples become considerably smaller. Likewise, our inferences also hold if we use ±0.1 cutoffs, with the natural caveat that our estimates become noisier as we then draw on observations that speak less to the predictions of our theory (firm-years with less pronounced association between cash flows and investment opportunities).

The second measure of investment opportunities that we consider is related to observed product-market demand. Specifically, for each firm-year in the sample we compute the median three-year-ahead sales growth rate in the firm's three-digit SIC industry and then compute the correlation between this measure of industry-level demand and the firm's cash flow. The premise of this approach is that firms' perceived investment opportunities may be related to estimates of future sales growth in their industries and that those estimates, on average, coincide with the ex post observed data. To be consistent with the first characterization of hedging needs, we also set cutoffs for high and low hedging needs at correlation coefficients of 0.2 and −0.2, respectively.

A detailed description of firms characterized as high and low hedging needs according to each of the criteria we just discussed is provided in the next subsection. While space considerations preclude us from reporting here an industry-by-industry analysis of our measures of hedging needs, we illustrate some basic characteristics of those measures by looking at two representative industries in our data. The first is "engineering and scientific instruments" (SIC 381), an industry that has 237 firm-years in our sample. Of the sample observations in SIC 381, 43 are classified as high hedging needs according to our R&D-based measure and 113 are classified as low hedging needs according to that same measure. When we reclassify firms' hedging needs according to the sales-based measure, we find that 56 observations are ranked as high hedging needs firms and 116 as low hedging needs firms. More interestingly, out of the 43 firm-years that are classified as high hedging needs according to our first measure, 42 are also classified as high hedging needs according to the second measure. As for the 113 firms classified as low hedging needs by the first measure, 96 of those firms are also classified as high hedging needs by the second measure.

The second industry we describe is "concrete, gypsum, and plaster products" (SIC 327). For this industry, there is a weaker correlation across our hedging needs measures. We have a total of 131 observations in SIC 327. According to the R&D-based (sales-based) measure of hedging needs, 35 (24) observations have high hedging needs, and 38 (31) have low hedging needs. Only 13 firm-years are similarly classified as high hedging needs (17 as low hedging needs) according to the two criteria; at the same time, the two measures only rarely yield opposite group assignments. Weaker correlations of this nature make it more difficult to identify our theory in the data, yet they do not introduce spurious biases in our tests.

### 4.3. Sample characteristics

Our tests need to identify groups of firms facing differential levels of financial constraints *and* hedging needs. To our knowledge, no previous study has differentiated firms along both of these dimensions. Accordingly, it is important that we highlight and discuss basic differences in firm characteristics across constrained/unconstrained and low/high hedging needs subsamples. Presenting these descriptive univariate statistics is interesting in its own right, but it also helps us assess the merits of candidate alternative explanations for our central (multivariate-based) empirical findings.[24]

[24] Note that sample summary statistics can only go so far in providing evidence of any theory on the *marginal* allocation of funds and financing decisions. We cannot, for example, use summary statistics on cash stocks to draw inferences about

Our analysis suggests the use of contrasts across four firm-types; these are based on the intersection of the degree of financial constraints and the degree of hedging needs. In our tests, we consider four measures of financial constraints and two measures of hedging needs. Thus, for every empirical variable we examine, our categorization scheme yields 32 ($= 4 \times 4 \times 2$) sets of subsample descriptives. In the interest of completeness and robustness, we summarize each of the main empirical proxies used in our analysis across all possible categorizations. This summary is provided in Table 2, which reports means and medians for beginning-of-period long-term debt to asset ratio (*Debt*), beginning-of-period cash to asset ratio (*CashHold*), net cash flow scaled by assets (*CashFlow*), the market-to-book asset ratio ($Q$), and the net difference between debt issuance and repurchase scaled by assets ($\Delta$*Debt*). The table also shows a standard measure of financial distress (*Z-Score*) in order to aid some of our discussion.[25]

Since our sampling approach and variable construction methods follow the existing literature, it is not surprising that the numbers we report in Table 2 resemble those found in related studies (e.g., Frank and Goyal, 2003 and Almeida et al., 2004). In particular, as in Frank and Goyal (2003), average leverage ratios fluctuate around 0.19 and average $Q$'s hover around 1.6. The figures for net debt issues and cash flows are also comparable across the two papers; note, however, that Frank and Goyal (2003) scale debt issuances by net (as opposed to total) assets.

Relevant for our purposes, there seems to exist only limited evidence that any of the variables examined in Table 2 vary systematically across the four firm-types we study. For example, constrained firms seem to carry more debt according to some characterizations (e.g., based on payout policy), but less according to others (e.g., size); in addition, there is no significant variation in debt policies across firms with high and low hedging needs within a given constraint type. Consistent with intuition, some characterizations suggest that constrained firms are more profitable and/or have higher growth opportunities. However, notice that

(1) these differences are not robust within and across the panels of Table 2,
(2) differences are economically insignificant (e.g., $Q$'s are economically similar across all firm-types), and
(3) there are no systematic differences between constrained firms with high and low hedging needs (even though some slight subsample patterns appear to arise, we have verified that they are generally statistically insignificant).

Statistics for cash holdings are similar to those in Almeida et al. (2004), whose study focuses on this particular variable. As in their paper, we also find that constrained firms hold far more cash, on average, than unconstrained firms. However, there is little systematic variation across firms with different hedging needs—although low hedging needs firm seem to carry more cash, differences across firm-types are most of the time statistically insignificant. Finally, we consider differences in financial distress measures across firms in our sample using Altman's $Z$-Score. One could argue that financial distress alone may drive differences in the way firms make their cash and debt choices. We have no priors as to why financial distress will influence our assignment of firms in a systematic way, but we let the data tell us if any patterns arise. The second

the dynamics of hedging needs and cash savings—at any point in time, a firm's observed cash stocks will reflect (i.e., confound) ex ante policies and ex post outcomes. Our multivariate analysis, in contrast, is designed to shed light on firms' hedging needs and marginal cash savings decisions following cash flow innovations.

[25] We use Altman's "unleveraged" $Z$-Score measure (also used by Frank and Goyal, 2003), which is computed as $3.3\times(\text{item \#170/item \#6}) + (\text{item \#12/item \#6}) + 1.4\times(\text{item \#36/item \#6}) + 1.2\times((\text{item \#4} - \text{item \#5})/\text{item \#6})$.

Table 2
Summary statistics for financial constraints and hedging needs

| Financial constraints criteria | Hedging needs | Variable: Mean [Median] | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Debt* | *CashHold* | *CashFlow* | *Q* | *Z-Score* | $\Delta$*Debt* |
| A. Hedging needs based on the correlation between firm cash flows and industry R&D | | | | | | | |
| 1. *Payout policy* | | | | | | | |
| Constrained firms | High hedging needs | 0.1968 | 0.1337 | 0.0201 | 1.5284 | 2.0386 | 0.0111 |
| | ($N = 2537$) | [0.1791] | [0.0830] | [0.0329] | [1.1906] | [2.1758] | [−0.0008] |
| | Low hedging needs | 0.2135 | 0.1447 | 0.0320 | 1.6361 | 2.0692 | 0.0096 |
| | ($N = 1585$) | [0.1991] | [0.0990] | [0.0385] | [1.2541] | [2.1354] | [−0.0019] |
| Unconstrained firms | High hedging needs | 0.1686 | 0.0845 | 0.0186 | 1.3758 | 2.4610 | 0.0133 |
| | ($N = 2459$) | [0.1590] | [0.0564] | [0.0161] | [1.1408] | [2.4076] | [−0.0001] |
| | Low hedging needs | 0.1703 | 0.0976 | 0.0242 | 1.5985 | 2.4272 | 0.0164 |
| | ($N = 1467$) | [0.1672] | [0.0601] | [0.0228] | [1.1802] | [2.3867] | [0.0000] |
| 2. *Firm size* | | | | | | | |
| Constrained firms | High hedging needs | 0.1478 | 0.1710 | 0.0315 | 1.5817 | 2.6141 | 0.0095 |
| | ($N = 2468$) | [0.1189] | [0.1352] | [0.0426] | [1.3050] | [2.7545] | [−0.0023] |
| | Low hedging needs | 0.1494 | 0.1787 | 0.0414 | 1.6500 | 2.5550 | 0.0063 |
| | ($N = 1574$) | [0.1229] | [0.1238] | [0.0450] | [1.2693] | [2.6696] | [−0.0030] |
| Unconstrained firms | High hedging needs | 0.1771 | 0.0743 | 0.0196 | 1.3420 | 2.1383 | 0.0119 |
| | ($N = 2427$) | [0.1671] | [0.0525] | [0.0202] | [1.1307] | [2.1401] | [0.0006] |
| | Low hedging needs | 0.1868 | 0.0938 | 0.0324 | 1.6882 | 2.1742 | 0.0125 |
| | ($N = 1545$) | [0.1828] | [0.0699] | [0.0305] | [1.2715] | [2.2180] | [0.0016] |
| 3. *Bond ratings* | | | | | | | |
| Constrained firms | High hedging needs | 0.1492 | 0.1334 | 0.0301 | 1.4189 | 2.6305 | 0.0075 |
| | ($N = 3351$) | [0.1334] | [0.0940] | [0.0342] | [1.1470] | [2.6839] | [−0.0018] |
| | Low hedging needs | 0.1536 | 0.1371 | 0.0367 | 1.5030 | 2.5729 | 0.0080 |
| | ($N = 2294$) | [0.1400] | [0.0947] | [0.0365] | [1.1556] | [2.6157] | [−0.0019] |
| Unconstrained firms | High hedging needs | 0.1908 | 0.0861 | 0.0266 | 1.4598 | 2.2460 | 0.0141 |
| | ($N = 4576$) | [0.1771] | [0.0573] | [0.0290] | [1.2147] | [2.2777] | [0.0000] |
| | Low hedging needs | 0.2032 | 0.1020 | 0.0360 | 1.7106 | 2.1966 | 0.0150 |
| | ($N = 2754$) | [0.1894] | [0.0694] | [0.0370] | [1.3326] | [2.2066] | [0.0000] |
| 4. *Commercial paper ratings* | | | | | | | |
| Constrained firms | High hedging needs | 0.1788 | 0.1245 | 0.0255 | 1.3877 | 2.4129 | 0.0110 |
| | ($N = 5124$) | [0.1632] | [0.0832] | [0.0305] | [1.1457] | [2.4785] | [−0.0015] |
| | Low hedging needs | 0.1854 | 0.1296 | 0.0346 | 1.5131 | 2.3557 | 0.0111 |
| | ($N = 3391$) | [0.1707] | [0.0870] | [0.0354] | [1.1864] | [2.4188] | [−0.0013] |
| Unconstrained firms | High hedging needs | 0.1654 | 0.0740 | 0.0328 | 1.5428 | 2.4022 | 0.0119 |
| | ($N = 2803$) | [0.1553] | [0.0528] | [0.0322] | [1.2656] | [2.3766] | [0.0000] |
| | Low hedging needs | 0.1735 | 0.0952 | 0.0397 | 1.8272 | 2.3947 | 0.0134 |
| | ($N = 1657$) | [0.1673] | [0.0692] | [0.0394] | [1.4117] | [2.3262] | [0.0004] |
| B. Hedging needs based on the correlation between firm cash flows and industry Sales Growth | | | | | | | |
| 1. *Payout policy* | | | | | | | |
| Constrained firms | High hedging needs | 0.2118 | 0.1338 | 0.0201 | 1.5537 | 2.0189 | 0.0114 |
| | ($N = 2039$) | [0.1909] | [0.0860] | [0.0357] | [1.2017] | [2.1566] | [−0.0016] |
| | Low hedging needs | 0.2137 | 0.1572 | 0.0233 | 1.6970 | 1.9567 | 0.0142 |
| | ($N = 1622$) | [0.1886] | [0.0979] | [0.0326] | [1.2807] | [2.0396] | [−0.0010] |
| Unconstrained firms | High hedging needs | 0.1834 | 0.0860 | 0.0202 | 1.3779 | 2.3732 | 0.0140 |
| | ($N = 2127$) | [0.1782] | [0.0580] | [0.0179] | [1.1609] | [2.3169] | [0.0000] |
| | Low hedging needs | 0.1685 | 0.0944 | 0.0218 | 1.6206 | 2.4605 | 0.0154 |
| | ($N = 1510$) | [0.1596] | [0.0619] | [0.0221] | [1.1922] | [2.3971] | [0.0000] |

(*continued on next page*)

Table 2 (*continued*)

| Financial constraints criteria | Hedging needs | Variable: Mean [Median] | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Debt* | *CashHold* | *CashFlow* | *Q* | *Z-Score* | $\Delta$*Debt* |
| 2. *Firm size* | | | | | | | |
| Constrained firms | High hedging needs | 0.1493 | 0.1629 | 0.0343 | 1.5772 | 2.5916 | 0.0080 |
| | ($N = 2276$) | [0.1253] | [0.1193] | [0.0434] | [1.2775] | [2.7400] | [−0.0032] |
| | Low hedging needs | 0.1518 | 0.1879 | 0.0344 | 1.7570 | 2.4955 | 0.0098 |
| | ($N = 1579$) | [0.1190] | [0.1423] | [0.0409] | [1.3342] | [2.6032] | [−0.0023] |
| Unconstrained firms | High hedging needs | 0.2106 | 0.0737 | 0.0215 | 1.3881 | 2.0033 | 0.0128 |
| | ($N = 2107$) | [0.2059] | [0.0506] | [0.0231] | [1.1572] | [2.0264] | [0.0013] |
| | Low hedging needs | 0.1737 | 0.0879 | 0.0286 | 1.6739 | 2.2410 | 0.0132 |
| | ($N = 1428$) | [0.1661] | [0.0573] | [0.0285] | [1.2668] | [2.2474] | [0.0000] |
| 3. *Bond ratings* | | | | | | | |
| Constrained firms | High hedging needs | 0.1486 | 0.1309 | 0.0329 | 1.4314 | 2.5899 | 0.0073 |
| | ($N = 2980$) | [0.1364] | [0.0971] | [0.0359] | [1.1559] | [2.6736] | [−0.0021] |
| | Low hedging needs | 0.1543 | 0.1495 | 0.0324 | 1.5466 | 2.5159 | 0.0087 |
| | ($N = 2196$) | [0.1371] | [0.1007] | [0.0334] | [1.1721] | [2.5257] | [−0.0016] |
| Unconstrained firms | High hedging needs | 0.2114 | 0.0883 | 0.0268 | 1.4835 | 2.1873 | 0.0156 |
| | ($N = 3801$) | [0.2024] | [0.0566] | [0.0305] | [1.2399] | [2.1511] | [0.0000] |
| | Low hedging needs | 0.2047 | 0.0969 | 0.0319 | 1.7057 | 2.2320 | 0.0155 |
| | ($N = 2836$) | [0.1857] | [0.0620] | [0.0356] | [1.3328] | [2.2763] | [0.0000] |
| 4. *Commercial paper ratings* | | | | | | | |
| Constrained firms | High hedging needs | 0.1822 | 0.1229 | 0.0278 | 1.4249 | 2.3533 | 0.0115 |
| | ($N = 4643$) | [0.1658] | [0.0851] | [0.0325] | [1.1595] | [2.4489] | [−0.0016] |
| | Low hedging needs | 0.1916 | 0.1339 | 0.0285 | 1.5156 | 2.3326 | 0.0125 |
| | ($N = 3392$) | [0.1733] | [0.0853] | [0.0314] | [1.1828] | [2.3779] | [−0.0011] |
| Unconstrained firms | High hedging needs | 0.1892 | 0.0739 | 0.0332 | 1.5380 | 2.3922 | 0.0129 |
| | ($N = 2138$) | [0.1831] | [0.0516] | [0.0337] | [1.3102] | [2.2707] | [0.0000] |
| | Low hedging needs | 0.1674 | 0.0923 | 0.0396 | 1.8858 | 2.4063 | 0.0126 |
| | ($N = 1640$) | [0.1535] | [0.0618] | [0.0407] | [1.4789] | [2.4018] | [0.0000] |

This table displays summary statistics for beginning-of-period long-term debt (*Debt*), beginning-of-period holdings of cash and liquid securities (*CashHold*), current cash flows (*CashFlow*), market-to-book asset ratio (*Q*), unleveraged Altman's *Z-Score*, and net debt issuance ($\Delta$*Debt*) across groups of financially constrained and unconstrained firms and firms with high versus low hedging needs. Hedging needs are measured based on the correlation between a firm's cash flow and various industry-level proxies for investment opportunities (these alternative measures are used in panels A and B). All data are from the annual COMPUSTAT industrial tapes and the sample period is 1971 through 2001.

to last column in each of the panels in Table 2 reveals no systematic relation between financial constraints, hedging needs, and financial distress.

One aspect of our characterization of the data that is new to the literature regards the propensity of firms to issue or repay debt given financial constraints and hedging needs. The mean and medians reported in the last column in each of the panels of Table 2 suggest that unconstrained firms, on net terms, seem to issue more debt than constrained firms. These statistics, however, say little about the frequency with which firms tap the debt markets. In unreported tables, we find that the frequency with which financially constrained and unconstrained firms act on their own debt accounts is not very different. The percentage of constrained firm-years that neither issue nor repurchase debt is in the 3–6% range (depending on the constraint criteria used), while the percentage of unconstrained firms that also do not act on their debt accounts is in a similarly low 3–6% range. We also find that constrained firms tend to make more trips to debt markets in order to repurchase debt (net repurchase activities are reported by 50–60% of the constrained firm-years), while unconstrained firms display the opposite pattern (net issuance frequencies in the 47–53% range). In other words, while rejecting the notion that constrained firms are largely inactive in the debt markets, our frequency tests reveal that constrained firms issue debt somewhat less frequently than unconstrained firms and manage their debt accounts with more frequent repurchase initiatives. Finally, we observe that the overall frequency of debt issuances and repurchases varies little across the dimension of hedging needs.

### 4.4. Debt and cash policies: constrained and unconstrained firms

Our testing approach requires us to compare the cash flow sensitivities of cash and debt estimated from Eqs. (23) and (24) across groups of firms sorted *both* on measures of constraints and of hedging needs. Before we do so, we perform preliminary estimations in which we consider only the differences between constrained and unconstrained firms; i.e., without sorting on hedging needs. The purpose of this is twofold. First, it is important to gage the average pattern of cash flow sensitivities for unconstrained firms: this pattern provides evidence on the net costs of cash and debt in the absence of constraints, and thus provides a benchmark against which to evaluate the results obtained for constrained firms. Second, these regressions allow for direct comparisons with previous papers in the literature on marginal financing decisions. While those papers do not consider the hedging dimension that we are exploring, it is important that we are able to replicate their primary findings in our data.[26]

Table 3 presents the results obtained from the estimation of our baseline regression system (Eqs. (23) and (24)) within each sample partition described in Section 4.2.2. A total of 16 estimated results are reported in the table (2 equations $\times$ 4 constraint criteria $\times$ 2 firm-types per constraint criterion). Results from the debt regressions (in panel A) make it clear that constrained firms, on average, display no propensity to alter their debt positions following a cash flow innovation. This is in sharp contrast to the policies of financially unconstrained firms. For each new dollar of excess cash flow, an unconstrained firm will reduce the amount of debt it issues by approximately 25 to 33 cents—the cash flow sensitivities of debt for unconstrained firms are all significant at better than the 1% test level. This negative relation between cash flows and debt issues is consistent with the findings of Shyam-Sunder and Myers (1999), among others, who report that debt issues are positively related to a firm's financing deficit for the types of firms that we classify as unconstrained.[27] In turn, results from the cash regressions (panel B) conform to those of Almeida et al. (2004). In particular, under each constraint criterion, the set of financially constrained firms show a significantly positive relation between excess cash flows and changes in cash holdings—their cash flow sensitivities of cash are all significant at better than the 1% test level. Unconstrained firms, in contrast, do not display any systematic propensity to save cash out of cash flows.

[26] We conduct all of our tests using a discrete ("high/low") firm groupings approach to assess the impact of our measures of financial constraints and hedging needs for a number of reasons. Firstly, the effects of those measures on firm behavior (e.g., investment) are less clear-cut at their intermediary levels. Secondly, this reflects a long-standing tradition in the literature on financial constraints (starting with the work of Fazzari et al., 1988). Thirdly, the interpretation of triple-interaction terms, which we would need to use if we were to adopt continuous proxies for our measures of financial constraints and hedging needs, becomes rather involved. Finally, by running our regressions in different group samples (as opposed to a single one) we allow the error term to vary across group estimations (had we imposed one single error structure our $t$-statistics would be inflated, potentially leading us to Type I inference errors).

[27] Note that Shyam-Sunder and Myers (1999) do not consider contrasts between constrained and unconstrained firms. However, their sample selection scheme ensures that only large firms with rated debt enter the sample, hence their results can be compared with our debt regressions for unconstrained firms.

Table 3
The cash flow sensitivity of debt and cash holdings

| Financial constraints criteria | Independent variables | | | | | $R^2$ | $N$ |
|---|---|---|---|---|---|---|---|
| | $CashFlow_{i,t}$ | $Q_{i,t}$ | $Size_{i,t}$ | $\Delta CashHold_{i,t}$ | $Debt_{i,t-1}$ | | |
| A. Cash flow sensitivity of debt (net debt issuance) | | | | | | | |
| 1. *Payout policy* | | | | | | | |
| Constrained firms | 0.0148 | −0.0077** | 0.0306** | 0.0980 | −0.2393** | 0.11 | 3338 |
| | (0.57) | (−3.26) | (9.40) | (1.63) | (−16.49) | | |
| Unconstrained firms | −0.3531** | 0.0004 | 0.0384** | 0.1464** | −0.3301** | 0.16 | 3835 |
| | (−21.03) | (0.20) | (12.32) | (2.77) | (−21.05) | | |
| 2. *Firm size* | | | | | | | |
| Constrained firms | −0.0037 | −0.0072** | 0.0365** | −0.0011 | −0.2720** | 0.11 | 3043 |
| | (−0.13) | (−3.16) | (9.40) | (−0.02) | (−17.11) | | |
| Unconstrained firms | −0.2408** | −0.0031* | 0.0240** | 0.2829** | −0.2493** | 0.10 | 4023 |
| | (−11.29) | (−1.93) | (10.41) | (3.24) | (−19.02) | | |
| 3. *Bond ratings* | | | | | | | |
| Constrained firms | 0.0642** | −0.0114** | 0.0330** | 0.0060 | −0.2629** | 0.11 | 3844 |
| | (2.74) | (−6.50) | (9.40) | (0.14) | (−17.70) | | |
| Unconstrained firms | −0.2330** | −0.0007 | 0.0240** | 0.1214** | −0.2708** | 0.13 | 7836 |
| | (−13.50) | (−0.49) | (10.41) | (2.54) | (−28.89) | | |
| 4. *Commercial paper ratings* | | | | | | | |
| Constrained firms | −0.0633** | −0.0044 | 0.0344** | 0.0359 | −0.2636** | 0.11 | 7039 |
| | (−3.43) | (−2.78) | (15.42) | (0.92) | (−25.94) | | |
| Unconstrained firms | −0.3183** | −0.0026 | 0.0262** | 0.2113** | −0.2811** | 0.14 | 4641 |
| | (−14.79) | (−1.61) | (10.93) | (2.91) | (−22.31) | | |
| B. Cash flow sensitivity of cash holdings | | | | | | | |
| 1. *Payout policy* | | | | | | | |
| Constrained firms | 0.1666** | 0.0100** | −0.0085** | 0.1826** | −0.3221** | 0.12 | 3338 |
| | (8.37) | (5.09) | (−2.82) | (3.72) | (−20.05) | | |
| Unconstrained firms | −0.0088 | 0.0016 | −0.0039 | −0.0344 | −0.3908** | 0.20 | 3835 |
| | (−0.54) | (1.35) | (−1.84) | (−1.16) | (−30.78) | | |
| 2. *Firm size* | | | | | | | |
| Constrained firms | 0.2201** | 0.0064** | −0.0154** | 0.1593** | −0.3323** | 0.14 | 3043 |
| | (9.26) | (2.85) | (−3.69) | (2.84) | (−19.89) | | |
| Unconstrained firms | 0.0026 | 0.0033** | −0.0042** | 0.0326 | −0.2385** | 0.09 | 4023 |
| | (0.19) | (3.53) | (−2.90) | (1.05) | (−19.52) | | |
| 3. *Bond ratings* | | | | | | | |
| Constrained firms | 0.1873** | 0.0059** | −0.0072* | 0.0770 | −0.3439** | 0.15 | 3844 |
| | (8.56) | (3.20) | (−2.09) | (1.39) | (−23.26) | | |
| Unconstrained firms | 0.0369* | 0.0049** | −0.0084** | 0.1002** | −0.2951** | 0.11 | 7836 |
| | (2.21) | (4.89) | (−5.82) | (4.34) | (−31.12) | | |
| 4. *Commercial paper ratings* | | | | | | | |
| Constrained firms | 0.1422** | 0.0073** | −0.0091** | 0.1422** | −0.3290** | 0.13 | 7039 |
| | (4.50) | (5.59) | (−4.42) | (4.50) | (−31.27) | | |
| Unconstrained firms | −0.0061 | 0.0032* | −0.0069** | −0.0061 | −0.2702** | 0.10 | 4641 |
| | (−0.22) | (3.13) | (−4.25) | (−0.22) | (−22.23) | | |

This table displays 3SLS-FE (firm and year effects) results of empirical models for debt issuance and cash holdings (see Eqs. (23) and (24) in the text). Panel A displays the results for long-term debt issuance (net of repurchases), while panel B displays the results for changes in the holdings of cash and liquid securities. All data are from the annual COMPUSTAT industrial tapes and the sample period is 1971 through 2001. The debt and cash models are jointly estimated (within constraint types) and the empirical error structure allows for unstructured correlation across models. $t$-statistics are in parentheses.

* Statistical significance at the 5-percent (two-tail) test level.

** Idem, 1-percent.

Our theory makes clearer predictions about the relationship between cash flow sensitivities and hedging needs than about the average level of those sensitivities across financial constraints alone. This is partly because the theory does not pin down the levels of the sensitivities for unconstrained firms, and partly because the average level of the sensitivities for constrained firms depends on the distribution of hedging needs across these firms. Nonetheless, one can rationalize the "average" results from Table 3 as follows. Unconstrained firms seem to display a preference towards using cash flows to reduce debt instead of holding cash in their balance sheets. This finding indicates that holding cash is relatively costly for these firms, perhaps because cash has low yield and/or it can be diverted by management (our examination need not take a stand on these exact costs). In contrast, constrained firms choose to retain cash *in spite* of the fact that cash retention may be costly. This finding alone suggests that cash has a relevant economic role to play when firms are financially constrained. Finally, the additional finding that debt is not systematically related to cash flows for constrained firms suggests that these firms *on average* prefer positive cash over negative debt.

To show that cash and debt policies of constrained firms are influenced by our theoretical predictions, we need to find evidence that these policies are significantly affected by hedging needs. We examine this issue in turn.

### 4.5. *Debt and cash policies: financial constraints and hedging needs*

The tests of this section consist of performing estimations of our 3SLS system across (double) partitions of constrained/unconstrained firms and firms with low/high hedging needs. Table 4 reports the results from those system estimations, separately for constrained firms (panel A) and unconstrained firms (panel B). That table features our first proxy for investment opportunities (that is, industry R&D expenditures) in the computation of the correlation between a firm's cash flows and the investment opportunities it faces. Table 5 is similarly compiled, but the results there concern our second measure of growth opportunities (based on industry sales growth). For ease of exposition, we only present estimates of the cash flow sensitivities of cash and debt in the 3SLS system; that is, $\alpha_1$ and $\beta_1$, respectively, in Eqs. (23) and (24).

Results in Tables 4 and 5 are all very similar and we discuss them jointly. As in previous estimations, unconstrained firms display a strong, negative cash flow sensitivity of debt—they use their free cash flow to cut down debt—and their cash policies are generally insensitive to cash flow innovations. Importantly, these patterns are largely unrelated to measures of hedging needs. To be precise, the cash flow sensitivities of cash are insignificant for the vast majority of unconstrained firm subsamples (both those with low and those with high hedging needs). And while cash flow sensitivities of debt are sometimes more negative for firms with low hedging needs, the reverse pattern occurs with almost the same frequency. As predicted, the estimates from regressions for unconstrained firms suggest that there is no systematic relation between hedging needs and either of the two cash flow sensitivities we analyze.

The results are strikingly different for financially constrained firms. Our estimations show that constrained firms with high hedging needs increase their borrowings following a positive cash flow innovation—estimates of the cash flow sensitivity of debt are positive and statistically significant in 7 of 8 the specifications we tabulate. These firms are also the ones doing the most cash savings in that their cash flow sensitivities of cash are uniformly positive—all such sensitivities are statistically significant. In sharp contrast, constrained firms with low hedging needs display a tendency to reduce their outstanding debt when they have cash flow surpluses, a pattern that is similar (but much weaker in magnitude) to that observed for unconstrained firms. Finally,

Table 4
Hedging needs (industry-level R&D measure) and the propensity to save cash vs. pay down debt

| Endogenous policy variable | Financial constraints criteria | | | |
|---|---|---|---|---|
| | Payout policy | Firm size | Bond ratings | CP ratings |
| A. Constrained firms | | | | |
| 1. *Debt issuance (net of retirements)* | | | | |
| Firms w/ High hedging needs | 0.0874* | 0.0568 | 0.1518** | 0.0642* |
| | (2.25) | (1.40) | (3.88) | (2.26) |
| Firms w/ Low hedging needs | −0.1071* | −0.1365* | −0.0812* | −0.2788** |
| | (−2.03) | (−2.30) | (−2.00) | (−8.42) |
| $p$-value of diff. high–low hedging | [0.00] | [0.01] | [0.00] | [0.00] |
| 2. *Increases in cash holdings* | | | | |
| Firms w/ High hedging needs | 0.2011** | 0.2571** | 0.2532** | 0.1852** |
| | (7.44) | (8.51) | (7.18) | (8.70) |
| Firms w/ Low hedging needs | 0.0481 | 0.0605 | 0.0987 | 0.0514 |
| | (0.97) | (0.92) | (1.95) | (1.42) |
| $p$-value of diff. high–low hedging | [0.01] | [0.01] | [0.01] | [0.00] |
| B. Unconstrained firms | | | | |
| 1. *Debt issuance (net of retirements)* | | | | |
| Firms w/ High hedging needs | −0.4277** | −0.1822** | −0.1712** | −0.4650** |
| | (−9.27) | (−3.50) | (−5.86) | (−10.85) |
| Firms w/ Low hedging needs | −0.5514** | −0.1565** | −0.3680** | −0.2071** |
| | (−12.75) | (−2.79) | (−9.74) | (−3.14) |
| $p$-value of diff. high-low hedging | [0.05] | [0.74] | [0.00] | [0.00] |
| 2. *Increases in cash holdings* | | | | |
| Firms w/ High hedging needs | 0.0356 | 0.0526 | 0.1087** | −0.0157 |
| | (1.12) | (1.63) | (5.75) | (−0.47) |
| Firms w/ Low hedging needs | 0.0198 | −0.0603 | −0.0396 | −0.0976* |
| | (0.28) | (−1.63) | (−1.11) | (−2.00) |
| $p$-value of diff. high–low hedging | [0.84] | [0.02] | [0.00] | [0.17] |

This table reports 3SLS-FE (firm and year effects) results of empirical models for debt issuance and cash holdings (see Eqs. (23) and (24) in the text). Each cell displays estimates of the coefficient returned for *CashFlow* (and the associated test statistics) separately for sets of firms with high hedging needs and for sets of firms with low hedging needs. Panel A displays the results returned for financially constrained firms, while panel B displays the results for financially unconstrained firms. All data are from the annual COMPUSTAT industrial tapes and the sample period is 1971 through 2001. The debt and cash models are jointly estimated (within constraint types) and the empirical error structure allows for unstructured correlation across models. $t$-statistics are in parentheses.

* Statistical significance at the 5-percent (two-tail) test level.

** Idem, 1-percent.

cash flow sensitivities of cash are never significant for constrained firms with low hedging needs. Noteworthy, this last result significantly qualifies the inferences in Almeida et al. (2004) regarding constrained firms' cash savings behavior. To wit, we show that those authors' results are driven solely by the subset of constrained firms that have high hedging needs.

We also report the $p$-values for the differences in cash flow sensitivities of cash and debt within constrained and unconstrained subsamples (i.e., across hedging needs subsamples). One central pattern is clear and independent of the choice of financial constraints and hedging needs measures: constrained firms with high hedging needs have *higher* cash flow sensitivities of cash and *higher* cash flow sensitivities of debt than constrained firms with low hedging needs. In fact, differences in cash flow sensitivities of cash and debt across high and low hedging needs

Table 5
Hedging needs (industry-level sales growth measure) and the propensity to save cash vs. pay down debt

| Endogenous policy variable | Financial constraints criteria | | | |
|---|---|---|---|---|
| | Payout policy | Firm size | Bond ratings | CP ratings |
| A. Constrained firms | | | | |
| 1. *Debt issuance (net of retirements)* | | | | |
| Firms w/ High hedging needs | 0.1380** | 0.1112** | 0.1921** | 0.1084** |
| | (3.58) | (2.61) | (5.51) | (3.89) |
| Firms w/ Low hedging needs | −0.1888** | −0.1768** | −0.1125* | −0.3041** |
| | (−3.79) | (−3.38) | (−2.34) | (−8.66) |
| *p*-value of diff. high–low hedging | [0.00] | [0.00] | [0.00] | [0.00] |
| 2. *Increases in cash holdings* | | | | |
| Firms w/ High hedging needs | 0.1997** | 0.2662** | 0.2180** | 0.1924** |
| | (3.99) | (4.44) | (3.97) | (3.96) |
| Firms w/ Low hedging needs | 0.0722 | 0.0526 | 0.0185 | 0.0834 |
| | (1.26) | (0.73) | (0.24) | (1.95) |
| *p*-value of diff. high–low hedging | [0.09] | [0.02] | [0.03] | [0.09] |
| B. Unconstrained firms | | | | |
| 1. *Debt issuance (net of retirements)* | | | | |
| Firms w/ High hedging needs | −0.3537** | −0.2966** | −0.1690** | −0.3996** |
| | (−9.93) | (−8.87) | (−5.96) | (−11.11) |
| Firms w/ Low hedging needs | −0.5718** | −0.1577* | −0.4109** | −0.3883** |
| | (−12.85) | (−2.12) | (−11.76) | (−7.23) |
| *p*-value of diff. high–low hedging | [0.00] | [0.10] | [0.00] | [0.86] |
| 2. *Increases in cash holdings* | | | | |
| Firms w/ High hedging needs | −0.0586 | 0.0436 | 0.0607 | 0.0171 |
| | (−1.29) | (1.45) | (1.35) | (0.44) |
| Firms w/ Low hedging needs | 0.0042 | 0.0335 | 0.0604 | −0.0875 |
| | (0.10) | (0.45) | (1.34) | (−0.90) |
| *p*-value of diff. high–low hedging | [0.30] | [0.90] | [1.00] | [0.32] |

This table reports 3SLS-FE (firm and year effects) results of empirical models for debt issuance and cash holdings (see Eqs. (23) and (24) in the text). Each cell displays estimates of the coefficient returned for *CashFlow* (and the associated test statistics) separately for sets of firms with high hedging needs and for sets of firms with low hedging needs. Panel A displays the results returned for financially constrained firms, while panel B displays the results for financially unconstrained firms. All data are from the annual COMPUSTAT industrial tapes and the sample period is 1971 through 2001. The debt and cash models are jointly estimated (within constraint types) and the empirical error structure allows for unstructured correlation across models. *t*-statistics are in parentheses.

* Statistical significance at the 5-percent (two-tail) test level.

** Idem, 1-percent.

constrained subsamples are significant at better than the 9% level (1% level) in all (in 12) of the 16 regression pairs we analyze.

The results reported in Tables 4 and 5 are entirely consistent with the predictions of our model (Implications 1–3 of Section 3.3). In a nutshell, constrained firms show a much stronger propensity to save cash out of cash flows and a much weaker propensity to reduce debt when their hedging needs are high. This pattern suggests that future investment needs, jointly with expectations about the availability of internal funds, are key determinants of those firms' financial policies. The fact that unconstrained firms do not display such policy responses gives additional evidence that the patterns we uncover in the data are produced by the joint, dynamic optimization of financing and investment that characterizes constrained firms' policies. These are precisely the sorts of firm behavior our tests have sought to identify through the use of multiple cross-sectional contrasts.

## 5. Concluding remarks

We show that cash and negative debt can play distinct roles in the intertemporal optimization of investment by financially constrained firms. In essence, firms can use different combinations of cash and debt in order to transfer resources across future states of the world. These transfers allow constrained firms to improve the match between financing capacity and investment opportunities, and therefore can be value-enhancing. Empirically, we show that constrained firms with high hedging needs prefer to allocate excess cash flows into cash holdings. In contrast, constrained firms with low hedging needs use excess cash flows towards reducing outstanding debt. These observed empirical links between hedging needs and financial policies conform with the predictions of our theory.

Our results suggest that there is an important hedging dimension to standard financial policies such as cash and debt in the presence of financing frictions. While the link between hedging and financing constraints was previously considered by Froot et al. (1993), the implications of this link for cash and debt had hitherto not been studied. In looking at cash and debt balances as hedging devices, we find evidence of activities by real-world firms that are consistent with the theoretical link between hedging and financing constraints. Such a match between theory and evidence has often eluded those researchers who focus on the use of derivatives as hedging tools. We also identify an empirical counterpart for the notion of hedging demand. Based on the correlation between firm-level cash flows and industry-level investment opportunities, our study suggests various easy-to-implement measures of hedging needs that future researchers may find useful (see, e.g., Rauh, 2006b).

Our analysis focused mostly on the substitution effect between cash and debt among financially constrained firms. However, our empirical finding that financially unconstrained firms, too, display a systematic preference for using excess cash flows to reduce debt suggests that other considerations are also at play in the data. These considerations could include, for example, issues such as the yield on cash relative to the firm's effective borrowing cost and the diversion of free cash flows by management. Future research should try to identify the effects of tax parameters, agency problems, and liquidity premiums, among others, on the substitutability between cash and debt in financial policy-making.

Finally, recent literature has shown the important role of lines of credit in managing liquidity needs. On the theoretical front, Holmstrom and Tirole (1998) focus on transfers of liquidity across firms and motivate the provision of lines of credit by financial intermediaries as a way of mitigating the adverse effects of systematic liquidity shocks. On the empirical front, Sufi (2006) shows that lines of credit are an important component of firms' overall financial policy and are employed for a wide variety of corporate finance purposes even by large firms in the US. Nevertheless, this literature has not embedded the dynamic management of cash and debt as a part of the firm's overall management of liquidity needs. In the context of our theory, lines of credit can be viewed as an effective way of transferring resources from today to low cash flow states in future.[28] Crucially, however, Sufi (2006) documents that the 'material adversity clause' in lines of credit is invoked more often than assumed by the prior literature, denying liquidity to

[28] "Effective" in the sense that a unit spent today to arrange a line of credit creates more than a unit of liquidity in low cash flow states, akin to the effect of debt retirement in high cash flow states.

firms precisely when their need for liquidity may be high. This implies that there is a role for cash management even in the presence of lines of credit: cash balances transfer resources to future in an *unconditional* fashion, unlike lines of credit which may be subject to *conditionality* from material adversity clauses. We believe that integrating the roles of cash and debt management with the arrangement and usage of lines of credit is likely to be a rewarding direction for future research on financial constraints and hedging.


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## Appendix A

### A.1. Proof of Eq. (18)

First, note that if $\tau[c_1 + c_L] \geqslant d_2^N(\Delta)$, the debt is fully repaid in all future date-2 states, and so:

$$D_0 + \Delta = d_2^N. \tag{25}$$

Notice also that $\frac{\partial d_2^N}{\partial \Delta} = 1$ in this range.

If $\tau(c_1 + c_L) < d_2^N \leqslant \tau(c_1 + c_L + g(I_L(\Delta)))$, we have:

$$D_0 + \Delta = \left[1 - (1 - p^*)\phi\right] d_2^N + (1 - p^*)\phi\tau(c_1 + c_L), \tag{26}$$

which gives:

$$d_2^N(\Delta) = \frac{[1 - (1 - p^*)\phi\tau]\Delta}{[1 - (1 - p^*)\phi]} + \frac{D_0 - (1 - p^*)\phi\tau[c_0 + c_L]}{[1 - (1 - p^*)\phi]}, \tag{27}$$

so that $k_1 = \frac{D_0 - (1-p^*)\phi\tau[c_0 + c_L]}{[1-(1-p^*)\phi]}$. Notice that in this range:

$$\frac{\partial d_2^N}{\partial \Delta} = \frac{[1 - (1 - p^*)\phi\tau]}{[1 - (1 - p^*)\phi]} > 1. \tag{28}$$

If $\tau(c_1 + c_L + g(I_L(\Delta))) < d_2^N \leqslant d_2^{\max}$, we have:

$$D_0 + \Delta = p^* d_2^N + (1 - p^*)\tau\left[c_1 + c_L + (1 - \phi)g\big(I_L(\Delta)\big)\right], \tag{29}$$

which gives:

$$d_2^N(\Delta) = \frac{[1-(1-p^*)\tau]\Delta - (1-p^*)\tau(1-\phi)g(I_L(\Delta))}{p^*} + \frac{D_0 - (1-p^*)\tau[c_0 + c_L]}{p^*}, \tag{30}$$

so that $k_2 = \frac{D_0-(1-p^*)\tau[c_0+c_L]}{p^*}$. In this case, $\frac{\partial d_2^N}{\partial \Delta}$ depends on $I_L(\Delta)$. We prove below (Lemma 1) that $\frac{\partial d_2^N}{\partial \Delta} > 1$.

### A.2. *Proof of Lemma 1*

Consider (11) when that expression is an equality. Differentiating both sides with respect to $\Delta$, we obtain

$$\begin{aligned}
\frac{\partial I^H}{\partial \Delta} &= (1-\tau) + \frac{\partial}{\partial \Delta}\big[\tau(c_1 + c_H + g_H) - d_2^N\big]^+, \quad \text{and} \\
\frac{\partial I^L}{\partial \Delta} &= (1-\tau) + q\frac{\partial}{\partial \Delta}\big[\tau(c_1 + c_H + g_L) - d_2^N\big]^+ \\
&\quad + (1-q)\frac{\partial}{\partial \Delta}\big[\tau(c_1 + c_L + g_L) - d_2^N\big]^+,
\end{aligned} \tag{31}$$

where we denote $g_s = g(I_s)$. $\Delta < \widetilde{\Delta} \leqslant \Delta_{\max}$ implies that $\tau(c_1 + c_L + g_L) < d_2^N \leqslant d_2^{\max}$. In this case we have that $\tau(c_1 + c_H + g_H) - d_2^N > 0$, $\tau(c_1 + c_H + g_L) - d_2^N > 0$, and $\tau(c_1 + c_L + g_L) - d_2^N < 0$, and so:

$$\begin{aligned}
(1-\tau g_H')\frac{\partial I^H}{\partial \Delta} &= 1 - \frac{\partial d_2^N}{\partial \Delta}, \\
(1-\tau q g_L')\frac{\partial I^L}{\partial \Delta} &= 1 - \tau + \tau q - q\frac{\partial d_2^N}{\partial \Delta}.
\end{aligned} \tag{32}$$

We can also use Eq. (18) to derive an expression for $\frac{\partial d_2^N}{\partial \Delta}$ in this range:

$$\frac{\partial d_2^N}{\partial \Delta} = \frac{p^* + (1-p^*)(1-\tau)(1-\tau g_L'(1-\phi)) - q\tau g_L'[1-\phi(1-p^*)\tau]}{p^* - q\tau g_L' + (1-p^*)\phi q \tau g_L'} \equiv \frac{B(\phi)}{A(\phi)}. \tag{33}$$

After some algebra, we obtain that:

$$B(\phi) - A(\phi) = (1-p^*)(1-\tau)\big[1 - \tau q g_L'\big(1-\phi(1-q)\big)\big] > 0. \tag{34}$$

Thus, $\frac{\partial d_2^N}{\partial \Delta} > 1$ in this range, implying that $\frac{\partial I^H}{\partial \Delta} < 0$. In addition, we have that:

$$\operatorname{sgn}\left(\frac{\partial I^L}{\partial \Delta}\right) = \operatorname{sgn}\left(1 - \tau + \tau q - q\frac{\partial d_2^N}{\partial \Delta}\right) = \operatorname{sgn}\big[(1-\tau)(1-q)A(\phi) - q\big[B(\phi) - A(\phi)\big]\big]. \tag{35}$$

After some algebra, we obtain:

$$(1-\tau)(1-q)A(\phi) - q\big[B(\phi) - A(\phi)\big] = (1-\tau)(1-\tau g_L')(p^* - q) > 0, \tag{36}$$

and so $\frac{\partial I_L}{\partial \Delta} > 0$.

### A.3. Proof of Proposition 1

The firm is financially unconstrained if there exists a choice of $\Delta$ that renders the firm unconstrained in state $L$, that is, there exists a $\Delta$ such that $I_L(\Delta) \geqslant I^{FB}$. If $\Delta^L_{\text{unc}} > \Delta_{\min}$, for any $\Delta \in [\Delta^L_{\text{unc}}, \Delta_{\max}]$, the firm is unconstrained and hence indifferent in picking any policy $\Delta$, because $I_H$ and $I_L$ are independent of $\Delta$ in this range. For $\Delta < \Delta^L_{\text{unc}}$, the firm is rendered constrained in state $L$, which can only reduce firm value. Thus, any $\Delta \geqslant \Delta^L_{\text{unc}}$ is optimal. If $\Delta^L_{\text{unc}} < \Delta_{\min}$, then the firm is unconstrained for all $\Delta$ and indifferent among all possible financial policies. This shows the first part of the proposition.

Consider now a firm that is financially constrained for all $\Delta$. In this case, the firm solves the maximization problem in (21), and $I^*_s(\Delta) = I_s(\Delta)$, the constrained investment levels given by (11). In this case, the first-order condition for an interior solution of $\Delta$ is that

$$\left[(1-p)(1-\phi)(g'_L - 1)\frac{\partial I^L}{\partial \Delta} + p\phi(g'_H - 1)\frac{\partial I^H}{\partial \Delta}\right] \tag{37}$$

is equal to zero.

We have by Lemma 1 that $\frac{\partial I^L}{\partial \Delta} > 0$, and $\frac{\partial I^H}{\partial \Delta} < 0$. Thus, if $\phi = 0$, the expression in (37) is always positive, whereby $\Delta^* = \Delta_{\max}$. At $\phi = 1$, (37) is always negative. The firm should reduce $\Delta$ until it either exhausts its internal funds, $\Delta^* = \Delta_{\min}$, or until it becomes unconstrained in state $H$, such that $\frac{\partial I^H}{\partial \Delta} = 0$. If the firm is unconstrained in state $H$, then Eq. (37) becomes positive for any $\phi < 1$. Thus, the firm is strictly worse off having $\Delta < \Delta^H_{\text{unc}}$. This argument implies that $\Delta^* = \max(\Delta_{\min}, \Delta^H_{\text{unc}})$. Note that it is also possible that $\Delta$ is so low that debt becomes riskless in state $L$ ($\Delta < \overline{\Delta}$). If this case is feasible ($\Delta_{\min} < \overline{\Delta}$), the firm will be exactly indifferent between any $\Delta$ between $\Delta_{\min}$ and $\overline{\Delta}$, so we assume w.l.o.g. that $\Delta^* = \Delta_{\min}$.

Next, we show that whenever $\Delta^*$ is interior, it is decreasing in $\phi$. Then, the existence of unique $\overline{\phi}$ and $\overline{\overline{\phi}}$ follows by the intermediate-value theorem. Denoting the objective function in (21) by $f(\Delta)$, we obtain that at the optimal $\Delta^*$:

$$\frac{\partial f}{\partial \Delta} = 0, \qquad \frac{\partial^2 f}{\partial \Delta^2} < 0. \tag{38}$$

By the implicit-function theorem, that is, taking derivative of the first order condition w.r.t. $\phi$, we obtain

$$\operatorname{sign}\left(\frac{\mathrm{d}\Delta^*}{\mathrm{d}\phi}\right) = \operatorname{sign}\left(\frac{\partial^2 f}{\partial \phi \partial \Delta}\right). \tag{39}$$

Using Eqs. (32) and (33), we can write the first order condition for an interior $\Delta^*$ as:

$$\begin{aligned}&\frac{p\phi(g'_H - 1)}{(1-\tau g'_H)}\frac{[A(\phi) - B(\phi)]}{A(\phi)} \\ &\quad + \frac{(1-p)(1-\phi)(g'_L - 1)}{(1-\tau q g'_L)}\frac{[(1-\tau+\tau q)A(\phi) - qB(\phi)]}{A(\phi)} = 0,\end{aligned} \tag{40}$$

or:

$$\begin{aligned}S(\phi) \equiv{}& \frac{(1-p)(1-\phi)(g'_L - 1)}{(1-\tau q g'_L)}\big[(1-\tau)(1-q)A(\phi) - q\big(B(\phi) - A(\phi)\big)\big] \\ &- \frac{p\phi(g'_H - 1)}{(1-\tau g'_H)}\big[B(\phi) - A(\phi)\big] = 0.\end{aligned} \tag{41}$$

Using the expression for $[B(\phi)-A(\phi)]$ (Eq. (34)) we can simplify this further:

$$\frac{S(\phi)}{(1-\tau)}=\frac{(1-p)(1-\phi)(g_L'-1)}{(1-\tau q g_L')}\big[(1-q)A(\phi)-q(1-p^*)C(\phi)\big]$$
$$-\frac{p\phi(g_H'-1)}{(1-\tau g_H')}(1-p^*)C(\phi)=0, \tag{42}$$

where $C(\phi)\equiv\frac{[B(\phi)-A(\phi)]}{(1-\tau)(1-p^*)}=1-\tau g_L'(1-\phi(1-\tau q))$. Notice that $(1-q)A(\phi)-q(1-p^*)C(\phi)=\frac{(1-\tau)(1-q)A(\phi)-q[B(\phi)-A(\phi)]}{(1-\tau)}=(1-\tau g_L')(p^*-q)>0$ (see Eq. (36)). We need to show that $\frac{\partial}{\partial\phi}[\frac{S(\phi)}{(1-\tau)}]<0$. We have:

$$\frac{\partial}{\partial\phi}\left[\frac{S(\phi)}{(1-\tau)}\right]=-\frac{(1-p)(g_L'-1)}{(1-\tau q g_L')}\big[(1-q)A(\phi)-q(1-p^*)C(\phi)\big]$$
$$+\frac{(1-p)(1-\phi)(g_L'-1)}{(1-\tau q g_L')}\frac{\partial[(1-q)A(\phi)-q(1-p^*)C(\phi)]}{\partial\phi}$$
$$-\frac{p(g_H'-1)}{(1-\tau g_H')}(1-p^*)C(\phi)-\frac{p\phi(g_H'-1)}{(1-\tau g_H')}(1-p^*)C'(\phi). \tag{43}$$

This equation implies that it is sufficient to show that $C'(\phi)>0$, and $\frac{\partial[(1-q)A(\phi)-q(1-p^*)C(\phi)]}{\partial\phi}<0$. We have:

$$C'(\phi)=\tau g_L'(1-\tau q)>0,$$
$$A'(\phi)=(1-p^*)\tau q g_L', \tag{44}$$

and thus:

$$\frac{\partial[(1-q)A(\phi)-q(1-p^*)C(\phi)]}{\partial\phi}=-(1-\tau)(1-p^*)\tau q^2 g_L'<0.$$

So $\frac{\mathrm{d}\Delta^*}{\mathrm{d}\phi}<0$.

### A.4. *Proof of Proposition 2*

By Proposition 1, if $\phi\leqslant\overline{\phi}$, the optimal policy is to choose $\Delta^*=\Delta_{\max}$, which by Eqs. (17) and (16) can be expressed as:

$$D_0+\Delta_{\max}=p^*\tau(c_0+\Delta_{\max}+c_H)+(1-p^*)\tau\big(c_0+\Delta_{\max}+c_L+(1-\phi)g_L\big). \tag{45}$$

We can use this equation to calculate $\frac{\partial\Delta_{\max}}{\partial c_0}$ as:

$$\frac{\partial\Delta_{\max}}{\partial c_0}=\frac{p^*\tau+(1-p^*)\tau(1-\phi)g_L'\frac{\partial I_L}{\partial c_0}}{(1-\tau)}>0, \tag{46}$$

since $\frac{\partial I_L}{\partial c_0}>0$.

Since $c_1=c_0+\Delta^{\max}$, we also obtain $\frac{\partial c_1}{\partial c_0}>0$. If $\phi>\overline{\overline{\phi}}$, notice that if the firm is constrained in state $H$ in the optimal solution it must be that $\Delta_{\min}>\Delta_{\text{unc}}^H$. Thus, $\Delta^*=\Delta_{\min}$, which implies that

$$\frac{\partial \Delta^*}{\partial c_0} = \frac{\partial \Delta_{\min}}{\partial c_0} = -1, \tag{47}$$

and $\frac{\partial c_1}{\partial c_0} = 0$.

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