On the Sensitivity of Corporate Cash Holdings and Hedging to Cash Flows

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Abstract. We investigate a firm's joint decision to hold cash and to hedge in the presence of financial constraints. The predictions are tested using a sample of manufacturing firms. We confirm the existing evidence of a positive sensitivity of cash holdings to cash flow for financially constrained firms. More importantly, we find a positive sensitivity of hedging to cash flow for constrained firms and, depending on the measure of financial constraints, for unconstrained firms as well. These results indicate that costly risk management activities, like other capital investments, are sensitive to funding resources.

Keywords: cash holdings, hedging, financial constraints

JEL classifications: G30, G32

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1. Introduction

We examine the joint determination of corporate decisions to hold cash and to hedge risk, with a focus on the sensitivities of cash holdings and hedging to cash flow. While a positive sensitivity of cash holdings to cash flow for financially constrained firms has been previously documented by Almeida et al. (2004), Han and Qiu (2007), and Denis and Sibilkov (2010), the sensitivity of hedging activities to cash flow has not been examined. This paper therefore contributes to a growing literature that examines the interactions among alternative ways of managing risk. This literature includes a number of papers that explicitly highlight that cash holdings and hedging are potentially substitute mechanisms for dealing with uncertain future cash flows and costly external capital,[2] as well as empirical papers that provide evidence that hedging decisions are related to a firm's access to financial resources.[3]

Our conceptual framework, and a review of the existing theoretical literature, suggests two potential forces that affect a financially constrained firm's response to an increase in cash flow. On one hand, the additional financial resources can increase cash holdings, which is a substitute for hedging, and therefore hedging can decrease as cash flows increase. On the other hand, hedging utilizes financial resources, which could have more valuable alternative uses especially for financially constrained firms, and therefore hedging can increase as cash flows increase.

We present two main empirical findings. First, our results confirm the previous empirical evidence indicating that financially constrained firms increase their cash holdings as their cash flow increases, but that unconstrained firms do not consistently increase their cash holdings when cash flows increase. Second, we find that higher cash flows, on average, increase the likelihood of hedging for financially constrained firms. However, depending on

[2] See Froot et al. (1993) for a seminal contribution on how hedging can reduce the impact of costly external capital. Recent theoretical contributions on the joint determination of hedging and cash holdings include Han and Qiu (2007), Bolten et al. (2011), Gamba and Triantis (2011), Mello and Parsons (2000), and Rampini and Viswanathan (2010 and 2011). Disatnik, Duchin and Schmidt (2011) empirically examine firms' decisions regarding derivative use and cash holdings. In contrast to this study that focuses on how firms respond to a change in cash flow, they focus on how managerial characteristics influence a firm's choice of cash flow hedging, cash holdings, and lines of credit.

[3] See e.g., Nance, Smith and Smithson (1993), Mian (1996), Tufano (1996), Geczy, Minton, Shrand (1997), Carter, Rogers, and Simkins (2006) Lin, Phillips, and Smith (2008), Lins, Servaes and Tufano (2010), and Rampini, Ufal, and Viswanathan (2011).

how we define financial constraints, we find mixed evidence for financially unconstrained firms: for some definitions of financial constraints, we find a positive sensitivity of hedging to cash flow and for other definitions we do not.

Moreover, the pattern of evidence on the sensitivity of hedging to cash flow is strikingly similar to the pattern of evidence from the literature on the sensitivity of capital investment to cash flow. More specifically, we find that when we use Fazzari et al.'s (1988) method for identifying financially constrained firms (firms that pay lower dividends), hedging by constrained firms is sensitive to cash flow, while hedging by unconstrained firms is not. This pattern is analogous to Fazzari et al.'s (1988) result that constrained firms' capital investment is more sensitive to cash flows than unconstrained firms. On the other hand, when using Kaplan and Zingales' (1997) method for identifying financially constrained firms, we find that both constrained and unconstrained firms have a positive sensitivity of hedging to cash flow and that hedging of constrained firms is less sensitive to cash flows than the hedging of unconstrained ones. This pattern is analogous to Kaplan and Zingales' (1997) result that capital investment is less sensitive to cash flows for constrained firms than for unconstrained firms.

The similarity of the evidence on the sensitivity of hedging to cash flow to the evidence on the sensitivity of capital investment to cash flow suggests that the decision to engage in hedging activities can be viewed similarly to a capital investment decision. The costs associated with establishing and maintaining a hedging operation support this interpretation.[4] Overall, the finding that an increase in a firm's cash flow increases the likelihood of hedging suggests that the propensity to engage in costly risk management depends on a firm's financial resources. This finding is consistent with recent evidence by Rampini, Ufal, and Vishnawathan (2011), which indicates that the propensity of firms in the airline industry to hedge jet fuel risk depends on the firm's financial resources.

Our conceptual framework is taken from Almeida et al. (2004) and Han and Qui (2007), but we incorporate costly hedging as a choice variable in addition to cash holdings.

[4]Moyen (2004) argues that the different results for the capital investment-cash flow sensitivity can be explained by the correlation between cash flow and investment opportunities and greater access to debt financing for firms classified as financially unconstrained by Kaplan and Zingales (1997). An analogous explanation to Moyen's (2004) explanation for the capital investment-cash flow relationship applies to the hedging-cash flow relation. As cash flow and capital investment opportunities increase, so do the benefits from hedging if for no other reason than an increase in the scale of operations.

In this framework, cash holdings benefit a financially constrained firm by providing funds to take advantage of worthy future investment opportunities, but cash holdings are also associated with tax and agency costs, and foregone current investment. Reducing the volatility of future cash flows, via hedging, shifts financial resources from states with high future cash flow to states with low future cash flows and thereby shifts funds to states when the marginal return on investment is higher on average. When hedging costs are modeled as being proportional to the size of the hedging position, we show that under some technical conditions an increase in current cash flows increases cash holdings and increases hedging. When hedging includes a fixed cost component, there is a range at the low end of cash flows for which the benefits of hedging do not cover the fixed costs and therefore firms forego hedging.

In addition, we draw on recent theoretical work by Rampini and Viswanathan (2010, 2011) and Bolton et al. (2011), who use continuous time dynamic models to examine the relationships between cash holdings, hedging, and investment. These papers suggest that firms that are severely financially constrained will not hedge, but that the extent of hedging will increase as financial resources increase. Bolton et al. (2011) also predict that firms with large cash reserves will not hedge.

Empirically, we analyze a sample of manufacturing firms with respect to both their cash holdings and hedging policies, and use two empirical methods to jointly estimate the determinants of cash holdings and hedging: a two-stage least squares (2SLS) framework for simultaneous equations, and a treatment effects model for self-selection. We utilize two definitions of cash holdings that have been used in the previous literature. The first one, following Almeida et al. (2004), measures cash holdings as the ratio of cash and short-term investments to total assets, while a second one, following Acharya et al. (2007), measures the ratio of cash and short-term investments to net assets (i.e. total assets less cash). We identify financially constrained firms based on the criteria used by Almeida et al. (2004), namely firm size, payout, and KZ Index.

With respect to firms' hedging activity, we focus on their propensity to hedge foreign currency risk, since it is easier to measure and interpret. Supportive of this approach, Bodnar et al. (1998) find in a 1998 survey, that foreign currency derivatives are the most commonly used class of derivatives. Empirically, we recognize in our measurement that firms can hedge in a variety of ways. While many firms use financial derivatives to manage their foreign currency risk,[5] others decide to use other hedging instruments such as issuing foreign debt or pursuing operational hedges (e.g. a company decides to open a division in a foreign country). As a consequence, we hand collect a binary measure of foreign currency hedging from the firms' annual reports. This variable equals one if a firm hedges foreign currency risk using either financial derivatives (i.e. foreign currency forwards or swaps) or by issuing foreign debt, and equals zero if the firm does not engage in foreign currency hedging activities.

The paper is organized as follows: we present the conceptual framework in Section 2, the data and the methodology in Section 3, and the empirical results in Section 4. A short summary concludes the paper.

2. Conceptual Framework and Hypotheses to be Tested

We use the framework developed by Almeida et al. (2004) and augmented by Han and Qiu (2007) to organize our thinking about a firm's decisions to hold cash and to hedge, and how these decisions change in response to an increase in operating cash flow. In this framework, a firm chooses the level of investment in period 0 and period 1, denoted by I_0 and I_1. These investments generate $F(I_0)$ and $G(I_1)$ in period 2. The time value of money is zero. The firm has cash on hand at time 0 equal to C_0 and will generate C_1 (which can be uncertain) at time 1.

With no uncertainty and no financial constraints, a value maximizing firm would choose I_0 and I_1 so that the marginal return from the last dollar invested equals a dollar, i.e., so that $F'(I_0) = 1$ and $G'(I_1) = 1$. In this setting, an increase in cash available in time 0 would not change investment decisions. If there was insufficient cash on hand to invest the optimal amount, the firm would raise the funds, and if there was excess cash on hand relative to the optimal investment amount, the firm would pay out the excess funds. The same analysis applies to period 1. There is no reason to hold cash or to hedge in this setting.

A financially constrained firm - one that does not have sufficient funding either from internal or external funds to invest the optimal amount - would behave differently. Investing

[5] Heng (1998), Nydahl (1999), Allayannis and Ofek (2001), and Carter et al. (2001) find that the use of currency derivatives reduces the foreign exchange exposure.

an additional dollar in period 0 prevents the firm from investing an additional dollar in period 1. With no uncertainty about cash flow in period 1 (or alternatively, an ability to hedge all risk at no cost), a value maximizing firm will invest in periods 0 and 1 so that the marginal return in each period is equated, i.e. so that $F^{'}(I_0) = G^{'}[E(I_1)]$. In this setting, optimal investment is less than the level of investment for an unconstrained firm. In addition, an increase in the cash available at time 0 would cause the firm to invest more at time 0, but also to retain some of the additional cash for additional investment at time 1. Thus, there should be a positive relation between cash flow and cash holdings. Almeida et al. (2004), Han and Qiu (2007), and Denis and Sibilkov (2010) present evidence consistent with this prediction.

As analyzed by Han and Qiu (2007), the introduction of uncertainty about the financial resources available in period 1 (C_1 in the framework) changes the behavior of financially constrained, value maximizing firms. Uncertainty about cash flow in period 1 makes the return on investment in period 1, $G(I_1)$, uncertain because the level of investment depends on the funds available. The firm therefore invests in period 0 so that the marginal return equals the expected value of the marginal return from investment in period 1: $F^{'}(I_0) = E[G^{'}(I_1)]$. Assuming that the marginal return on investment in period 1 is convex ($G^{'''}(I_1) > 0$), the expected marginal return on period 1 investment is greater than the marginal return on expected investment ($E[G'(I_1)] > G'[E(I_1)]$).[6] A comparison of the first order conditions in this case with the previous case indicates that the marginal return from investment at time 0 in this setting is greater than the marginal return from investment at time 0 when risk can be hedged at zero cost. The higher marginal return implies a lower level of investment in period 0, all else equal, and more cash holdings. Han and Qiu (2007) call this the precautionary motive for holding cash, consistent with Keynes (1936). In response to an increase in cash flow in period 0, the firm would invest more and increase cash holdings, just as in the previous case. In response to an increase in uncertainty in period 1 (which is what Han and Qiu (2007) emphasize), the firm would hold more cash for precautionary purposes. Han and Qiu (2007) find evidence consistent with this prediction.

Although the uncertainty of cash flow in period 1 is exogenous in Han and Qiu's (2007) model, they discuss the impact of hedging on cash holdings. Since hedging reduces uncertainty about cash flow in period 1, they posit that all else equal greater hedging would

[6] See Kimball (1992) for related conditions for individual utility maximizing agents.

be associated with lower precautionary cash holdings. In the appendix, we investigate this issue further by augmenting the Almedia et et al. (2004) and Han and Qui (2007) model to incorporate costly endogenous hedging (and costly endogenous cash holdings), where hedging occurs through a forward contract and a proportional hedging cost equal to ε per dollar of notional principle is incurred at time 0. This cost can be viewed as capturing transaction, operational, and collateral costs for on-going hedging operations.[7] The ability to hedge implies that the amount of uncertainty about cash flow in period 1 is endogenous.

For expositional purposes, assume that the forward contract is written on a variable, p_1, which is negatively correlated with operating cash flows at time 1 (think of p_1 as the price of an input into the production process). The first order conditions imply the following relationships at the optimal level of cash holdings and hedging:

$$F'(I_0) = (1\text{-}\rho)\ \mathrm{E}\ G'(I_1) = \frac{1}{\varepsilon}\,\mathrm{Cov}\,[G'(I_1)\ ,\ p_1\ ],$$

where ρ equals the per dollar cost of holding cash. In words, an additional dollar saved from period 0 to period 1 costs the firm $F'(I_0)$ cash flow, which must equal the expected additional cash flow from investing that dollar in period 1, $(1-\rho)EG'(I_1)$, which must also equal the marginal value of using that dollar to hedge, where (1/ε) is the amount of hedging that can be done with a dollar and the covariance term captures the marginal expected benefit of an additional dollar of hedging.[8]

Now consider the effect of a change in cash flow in period 0 on cash holdings and hedging. Almeida et al. (2004), using a model with certain period 1 cash flow (or costless hedging of cash flow), and Han and Qiu (2007), using a model with uncertain cash flow and exogenous partial hedging, show that an increase in cash flow in period 0 increases cash holdings. Intuitively, additional cash flow is divided between current investment and future

[7] Hedging is also likely to have a fixed cost component, which we discuss shortly. These fixed costs include the cost of hiring the staff and purchasing the equipment necessary to trade and track derivative positions. Because of these fixed costs, firms are unlikely to switch back and forth in their use of derivatives. In fact, in our sample we only counted three cases in which firms dropped their existing hedging program in one year and then restarted it the following year. There was no instance in which firms implemented a hedging program for the first time and then dropped it after a couple of years. Unfortunately, due to the nature of the hedging data, we cannot provide any insights on the expansion or the reduction of foreign currency risk hedging activities.

[8] Intuitively, hedging shifts investment in period 1 from high cash flow states (which correspond to low values of p_1) to low cash flow states, or equivalently from states with relatively low values of $G'(I_1)$ to states with high values of $G'(I_1)$. Thus, the marginal return from an additional dollar of hedging depends on the covariance between p_1 and $G'(I_1)$.

investment (via additional cash holdings) so that the returns from investment in the two periods are equated at the margin. With endogenous costly hedging and endogenous costly cash holdings (the model in the appendix), the impact of additional cash flow on cash holdings and hedging is not obvious. If the firm retains some of the additional cash flow, then one might expect that hedging would decrease, reasoning that hedging and cash holdings are substitute means of dealing with the future uncertainty in cash flow. On the other hand, since hedging is costly, if some of the additional cash flow is used to increase the extent of hedging, cash holdings could decrease. In the appendix, we show that if some technical conditions hold (these are also shown to be sufficient conditions to make the second order conditions hold), then both hedging and cash holdings increase in response to an increase in cash flow in period 0. The sufficient conditions relate to the covariance between the underlying of the forward contract, p_1, and the second derivative of $G(I_1)$. We do not have intuition for what would be a reasonable sign or magnitude for these covariance terms and therefore simply accept them as technical conditions.

To summarize, this simple model with proportional hedging costs highlights that hedging involves the use of cash flow for which there are alternative uses (current investment, I_0, cash holdings for next period investment, R_0), and that one of these uses – cash holdings is a potential substitute for hedging. As consequence, there are potentially complicated tradeoffs associated with how value maximizing firms would respond to an increase in cash flow. Nevertheless, under some conditions, the model predicts that an increase in cash flow will lead to an increase in hedging and cash holdings.

Although not explicitly modeled in the appendix, we now consider the consequences of adding a fixed hedging cost. By a fixed cost, we mean a cost that would be incurred at time 0 if the firm hedges regardless of the size of the hedge position. The fixed cost implies that the benefits of hedging and therefore the size of the hedge position must be of sufficient magnitude to cover the fixed cost. As a consequence, there will be a range of low cash flows in period 0 for which the net benefits of hedging do not exceed the fixed costs and therefore an increase in cash flows in this range will not be sufficient to induce the firm to hedge.

Once cash flows increase outside of this low range, the firm will hedge and the model predicts that hedging will increase as cash flows increase.[9]

Additional insight about the interaction between cash holdings and hedging can be obtained from papers that use continuous time dynamic models as opposed to the static model discussed above. In Mello and Parsons (2000), a financially constrained firm is subject to multiple sources of uncertainty (one of which can be hedged) and liquidation occurs if the firm's cash balance falls too low. The firm chooses at each instant whether to operate or not (which is irreversible) and the amount of hedging. In their model, cash holdings is not a choice variable, instead it evolves over time conditional on the firm's operating and hedging decisions. They show that the amount of hedging is negatively related to a financially constrained firm's cash balance, i.e., a greater cash balance substitutes for hedging. Furthermore, they predict that the collateral costs associated with a hedge position can cause severely constrained firms not to hedge.

A series of papers, Rampini and Viswanathan (2010, 2011) and Rampini, Sufi, and Viswanathan (2011), highlight that hedging requires collateral and that the collateral costs can cause financially constrained firms to forego hedging so that the available financial resources can be used for investment purposes. Rampini, Sufi, and Viswanathan (2011) present empirical evidence on jet fuel hedging by airlines that is consistent with the theoretical predictions. More specifically, they show a positive relation between net worth and the extent of hedging. They also show that firms approaching financial distress reduce their hedging, while firms emerging from financial distress increase their hedging.

In Bolton, Chen and Wang (2011), a capital constrained firm chooses investment, cash holdings, and hedging while facing equity financing, real capital adjustment, cash holding, and hedging costs. The state variable in their model is the firm's cash-to-capital ratio. When the cash-to-capital ratio is high, the firm does not hedge. Intuitively, the benefit of hedging is low because of the relatively large amount of cash that is available to fund future investment. On the other hand, when the cash-to-capital ratio is very low, the absolute amount of hedging approaches zero. Intuitively, even though the potential benefit of hedging is high, the firm is cash constrained and so the costs of using some of that cash to hedge is even higher. This result is analogous to the result in Rampini and Viswanathan

[9] At the other extreme, if cash flows are so high that the firm is effectively unconstrained (which is outside of the model), then the firm would also forego hedging to avoid the hedging cost.

(2010) that severely financially constrained firms forego hedging so that cash is available for future investment. Thus, in the Bolton et al. (2011) model, the absolute amount of hedging is non- monotonically related to the cash-to-capital ratio: For low values of cash-to-capital, hedging is zero; as cash-to-capital increases over an intermediate range, hedging increases; and for high value of the cash-to-capital ratio, the firm does not hedge.[10]

In summary, the theoretical literature indicates two main forces affecting the relation between hedging and the firm's financial resources. On one hand, because additional financial resources can act as a substitute for hedging, hedging can decrease as cash flows increase. On the other hand, hedging utilizes financial resources which could have more valuable alternative uses, especially for financially constrained firms, and therefore hedging will increase as cash flows increase.

3. Empirical Analysis

3.1 Overview of the Approach

As with most of the existing literature, we cannot observe the extent of hedging that a firm undertakes, and therefore we estimate models for likelihood that a firm hedges versus that it does not hedge. The underlying assumption is that once the net benefits of hedging increase beyond a critical threshold, the firm hedges. Our main focus is on how cash flow influences the net benefits of hedging and cash holdings. That is, we estimate the sensitivity of cash holdings to cash flow and the sensitivity of the likelihood of hedging to cash flow for financially constrained firms and for unconstrained firms. More specifically, we estimate equations of the following form (more details are given below):

$$\Delta CH = \alpha_1 \, Hedges + \alpha_2 \, CASHFLOW + \alpha_3 \, X + \varepsilon$$

$$Prob(Hedges = 1) = F[\gamma_1 \, \Delta CH + \gamma_2 \, CASHFLOW + \gamma_3 \, Z + \omega],$$

where ΔCH is the change in cash holdings, $Hedges$ is a dichotomous variable indicating whether the firm hedges, $CASHFLOW$ is cash flow, X and Z are vectors of other explanatory variables (see below), and ε and ω are error terms. Our focus is on the estimates of α_2 and γ_2, and whether these estimates are greater for financially constrained firms than

[10] Gamba and Triantis (WP, 2011) also use a dynamic model to examine the tradeoffs and impacts on value of cash holdings, hedging, and operating flexibility.

unconstrained firms. We also examine the signs of α_1 and γ_1. If cash holdings and hedging are substitutes, α_1 and $\gamma_1$should be negative.

3.2 Data and Methodology

We use a sample of manufacturing firms over the 1997 to 2004 period. We use *CRSP* for stock returns, *Compustat* for accounting information, and we hand collect hedging and managerial compensation data. Given missing data, the final sample used for estimation has 318 firms and 841 observations, with each firm having as little as one observation and as many as eight observations.

Identifying Financially Constrained Firms

We use various measures of financial constraints. Following Almeida et al., we sort firms based on firm size, payout (dividend and repurchases) and KZ Index.[11] The KZ Index (based on Kaplan and Zingales (1997) and Lamont et al. (2001)) is constructed as follows:

$$\text{KZ Index} = -1.002 * \text{CF} + 0.283 * \text{Q} + 3.139 * \text{Lev} - 39.368 * \text{Div} - 1.315 * \text{CH}$$

where CF stands for cash flow, Q is Tobin's Q, Lev is leverage, Div represents the dividend ratio, and CH is cash holdings defined as the ratio of cash and short-term investments to total assets. All of these variables are computed using the original definitions of Kaplan and Zingales (1997). A higher KZ Index means that the firm is less financially constrained, and thus we expect a negative correlation with the other measures of financial constraints used in this study.

For each one of the financial constraint measures, we divide the sample into two groups based on the median values of each measure.[12] The means for all measures of

[11] Some authors also use bond and commercial paper ratings as measures of financial constraints. We are concerned about using them for two reasons. First, few of the firms in our sample have available bond and commercial paper ratings, and thus it would restrict even further the sample size available for estimation. Second, classifying firms that have bond or commercial paper ratings as financially unconstrained, and firms that do not have bond or commercial paper ratings as financially constrained is likely to categorize some constrained firms into the unconstrained sample, because ratings are slow to respond to changes in firm conditions (Löffler (2005)). Nevertheless, we did use this methodology with the available data. Results are not reported, but available upon request. They show a positive sensitivity of cash holdings to cash flow for financial constrained firms as determined by bond ratings, and a positive sensitivity of hedging to cash flow for financially unconstrained firms.

financial constraints and for all variables (both dependent and independent) are reported in Table 1. Table 2 indicates that the correlation coefficient between the Size and the KZ Index is high in absolute terms (-0.57), but that the correlations with Payout are relatively small.

Empirical Model

We model the joint determination of hedging and cash holdings with the following simultaneous equations model:

$$\begin{cases} \Delta CH_{i,t} = \alpha_0 + \alpha_1 Hedges_{i,t} + \alpha_2 CASHFLOW_{i,t} + \alpha_3 Size_{i,t} + \alpha_4 Q_{i,t} + \alpha_5 TaxRate_{i,t} \\ \quad + \alpha_6 lag\Delta CH_{i,t} + \alpha_7 Expenditures_{i,t} + \alpha_8 Acquisitions_{i,t} + \alpha_9 \Delta NWC_{i,t} \\ \quad + \alpha_{10} \Delta StDebt_{i,t} + \varepsilon_{i,t} \\ Hedges_{i,t} = \gamma_0 + \gamma_1 \Delta CH_{i,t} + \gamma_2 CASHFLOW_{i,t} + \gamma_3 Size_{i,t} + \gamma_4 Q_{i,t} + \gamma_5 FSales_{i,t} \\ \quad + \gamma_6 SOptions_{i,t} + \gamma_7 RestSt_{i,t} + \gamma_8 RDExpense_{i,t} + \gamma_9 TLCF_{i,t} + \omega_{i,t} \end{cases}$$

where the $\Delta CH_{i,t}$ represents the cash holdings and is a continuous endogenous variable, while $Hedges_{i,t}$ represents the net benefits of foreign currency hedging for firm i in year t. We do not observe $Hedges_{i,t}$, but instead observe a dichotomous variable, which equals 1 if the firm hedges foreign currency risk (the net benefits are positive), and 0 otherwise (the net benefits are negative). We therefore estimate

$$Probability(Hedges_{i,t} > 0) = F(\gamma X),$$

where F is the cumulative normal distribution function, γ is the vector of parameters, and X is the vector of right hand side variables in the second equation. $CASHFLOW_{i,t}$ equals the cash flow for firm i in year t, and is our independent variable of interest. Its estimated coefficients ($\hat{\alpha}_2$ and $\hat{\gamma}_2$) represent the sensitivity of cash holdings and hedging to cash flow. The other explanatory variables are described in Appendix 2. and their inclusion in the equations is motivated in the following subsections. $\varepsilon_{i,t}$ and $\omega_{i,t}$ are the error terms.

The first regression equation is similar to the one used by Almeida et al. (2004) and Denis and Sibilkov (2010), both of which have examined the sensitivity of cash holdings to cash flow, but also includes tax rates and lag of cash holdings as determinants of the change in cash holdings. The second equation, with $Hedges_{i,t}$ as the dependent variable, has not

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[12] Due to the sample size, we chose to work with the entire sample as opposed to the top and bottom three deciles. We replicated the tests by using the top and bottom three deciles, and the results are similar.

been estimated in the literature in this context. However, there have been numerous studies examining the determinants of hedging that use the variables on the right hand side of the second equation, with the exception of cash flows (see e.g., Nance et al. (1993), Mian (1996), Fok et al. (1997), and Geczy et al. (1997)).

We estimate the structural system of equations in two ways. First, we implement a two-stage estimation method (2SLS) to provide consistent estimates for the coefficients and corrected standard errors. In the first stage, we separately run an OLS regression for the cash holding decision and a probit regression for the hedging decision. In the second stage, we simultaneously estimate the two structural equations by including the predicted values from the first-stage regressions as explanatory variables. The variables on CEO compensation ($\mathrm{SOptions}_{i,t}$ and $\mathrm{RestSt}_{i,t}$) are used as instruments to identify the risk management activity. Similarly to Almeida et al. (2004), we also use instruments for the endogeneity between financial and investment decisions (in which the variables expenditures, acquisitions, change in net working capital, and short-term debt are considered endogenous). These instruments are: two lags of the level of fixed capital, lagged acquisitions, lagged net working capital, lagged short-term debt, and twice-lagged sales growth.

Second, we estimate a treatment effects model in which the hedging variable is included on the right hand side of the first equation (dependent variable is the change in cash holdings), but the change in cash holdings is not included on the right hand side of the second equation (dependent variable is the dichotomous variable Hedges). We use the Heckman (1979) two-step procedure, which corrects for self-selection (Li and Prabhala (2007)) with respect to hedging. More specifically, we use a probit model to estimate the second equation, and then include the inverse mills ratio from this equation on the right hand side when we estimate the first equation using ordinary least squares (with corrected standard errors). The treatment effects model controls for the unobservable private information motivating a firm's decision to hedge its foreign currency risk exposure. As with the previous estimation, we implement the treatment effects model with both definitions of cash holdings.

Dependent Variables

The dependent variable used in the first regression from our system of equations is the change in cash holdings ($\Delta\mathrm{CH}$). We investigate two definitions of cash holdings that have been used in the previous literature. The first definition (Def1), following Almeida et al. (2004), measures cash holdings as the ratio of cash and short-term investments to total assets. The second definition of cash holdings (Def2), following Acharya et al. (2007), measures the ratio of cash and short-term investments to net assets (i.e. total assets less cash). The results are similar and thus we report only the results for Def1, since it has been more widely used in the literature. Results from estimation using Def2 are available upon request.

The dependent variable used in the second regression is a binary variable (Hedges) indicating whether the firm hedges foreign currency risk (1 if a firm uses foreign currency hedging instruments, and 0 if the firm does not use foreign currency instruments). We find that 50.3% of the firms in our sample hedge in all years in which they are observed, 43.1% do not hedge in any year, and 6.6% change from no hedging to hedging and the reverse. Unfortunately, in cases where they do hedge, we do not have data on whether they increase or decrease their hedging activity level. As reported in Table 1, the average change in cash holdings is 0.5% of total assets.

Independent Variables

Common control variables for both regression equations are firm size (Size) and Investment Opportunities (Q), as the literature has identified them as important determinants of both changes in cash holdings and hedging activity. Firm size (Size) has been previously associated with economies of scale in cash management, and thus larger firms hold more cash (Almeida et al. (2004) and Denis and Sibilkov (2010)). Similarly, large firms are more likely to hedge than small firms (Block and Gallagher (1986), Nance et al. (1993), Booth et al. (1994), Mian (1996), Tufano (1996), Geczy et al. (1997), etc.), mainly due to economies of scale.

Investment Opportunities (Q) as measured by Tobin's Q is expected to be negatively associated to changes in cash holdings (Kim et al. (1998), Opler et al. (1999), Mikkelson and Partch (2003), and Harford et al. (2003)). On the other hand, investment opportunities have generally been positively associated with firm's hedging (Nance et al. (1993)). However, Geczy et al. (1997) found no significant relation between the two, while Mian's (1996) results indicate conflicting evidence across different measures used for investment opportunities. More recently, a theory paper by Morellec and Smith (2007) shows that hedging can control for both underinvestment and free cash flow problems.

Determinants used that are specific to changes in cash holdings are: marginal tax rates (TaxRate), lag change in cash holdings (lagΔCH), expenditures (Expenditures), acquisitions (Acquisitions), change in net working capital (ΔNWC), and short-term debt (ΔStDebt). The latter four (also used by Almeida et al. (2004)) are expected to have a negative relationship with the change in cash holdings, since less cash flow will be available as these variables increase.

Marginal tax rates (TaxRate) have not been considered by Almeida et al. (2004) and Denis and Sibilkov (2010), but we include them as a proxy for a firm's cost of holding cash.[13] We expect a negative relationship: a higher cost will make it more expensive for the firm to hold cash. The correlation of this variable with tax loss carry forward (TLCF) included in the second regression is -0.10 for the full sample.

Lag change in cash holdings (lagΔCH) is used to control for the serial correlation in a firm's change in cash holdings. If there is a pattern in a firm's decisions to save cash, this variable will capture it, much like a firm fixed effect for an unobserved yet repetitive action. Again, this variable has not been considered by Almeida et al. (2004) and Denis and Sibilkov (2010) in their change in cash holdings regression, but we include it in our framework as an exogenous independent variable. We expect the lagged change in cash holdings to be uncorrelated with the structural errors.

Determinants used that are specific to firm's hedging activity are: foreign sales (FSales), stock options awarded to the CEO (SOptions), restricted stock awarded to the CEO (RestSt), expenses with research and development (RDExpense), and tax loss carry forward (TLCF).[14]

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[13] We thank John Graham for kindly providing marginal tax rate data.

[14] Some authors argue for a positive relation between hedging and firm leverage (Leland (1998), and Cooper and Mello (1999)), while others do not find such a relationship (Block and Gallagher (1986) and Geczy et al. (1997)). However, if it exists, this relationship is plagued by endogeneity (Leland (1998) and Fehle and Tsyplakov (2005)). Since firms choose their hedging and financing simultaneously, adding leverage to the hedging – cash flow sensitivity regression would lead to a simultaneity bias and an inconsistent estimation. To avoid this problem and following the investment to cash flow sensitivity literature (Moyen (2004)), we do not include leverage as an independent variable in our main regressions.

The ratio of foreign sales on total sales (FSales) is used as a proxy for foreign currency exposure. According to Jorion (1991), foreign sales represent an appropriate proxy that controls not only for the extent of the exposure, but also for the economies of scale that take place when hedging foreign currency risk. The higher a firm's foreign currency exposure, the more it is expected to hedge (Adler and Dumas (1984)).

Stock options (SOptions) awarded to the CEO, because of their convex payoff structure, can lead to risk taking, and thus a lower likelihood of hedging (Tufano (1996)). Restricted stock (RestSt), on the other hand, gives a CEO an incentive to reduce risk through hedging (Tufano (1996)).

Expenses on research and development (RDExpense) are used as a proxy for asset intangibility. Firms that have more intangible assets are more likely to hedge in order to secure funds for future projects (Fok et al. (1997)). Tax Loss Carry Forwards (TLCF) are thought to have a positive relationship with firm's hedging activity as tax convexity increases firms' incentives to hedge (Graham and Smith Jr. (1999)). However, Graham and Rogers (2002) do not find evidence that firms actually hedge in response to tax convexity.

Mean values for the independent variables are presented in Table 1 for the whole sample, as well as for each of the sub-samples determined by different measures of financial constraints. On average, financially constrained firms have lower cash flows, smaller distance to default, smaller size, lower payout ratio, lower change in the short-term debt, lower expenditures, lower acquisitions, and to face lower marginal tax rates than financially unconstrained firms. They also award less stock options and restricted stock to executives.

4. Results

The results of the two-stage estimation for simultaneous equations (2SLS) and the treatment effects models are presented in Tables 3-5. Each table uses a different measure of financial constraints. The two empirical approaches yield very similar results in terms of both sign and magnitude of the estimated coefficients.

Nevertheless, the inclusion does not alter our conclusions. See Lin, Phillips, and Smith (2006) for an empirical analysis of hedging, and financing taking into account the endogeneity issues.

4.1 Sensitivity of Cash Holdings and Hedging to Cash Flow

The results indicate that, regardless of the measure used for financial constraints or the cash holdings definition, financially constrained firms exhibit a positive sensitivity of cash holdings to cash flow. On the other hand, for financially unconstrained firms, the coefficient on the cash flow variable is not significantly different from zero. These findings are consistent with the prior literature (Almeida et al. (2004), Han and Qiu (2007), and Denis and Sibilkov (2009)).

Regarding the likelihood of hedging, we find, regardless of the measure of financial constraints used, a positive and significant sensitivity of foreign currency hedging to cash flow for financially constrained firms. To illustrate the economic significance of the effect, consider the case where financial constraints are measured by Size (Table 3). The coefficient on the cash flow variable of 1.8 indicates that, for a firm that does not currently hedge ($\text{Hedges} = 0$) and has mean values for all of the right hand side variables, a 10% increase in cash flow would increase the likelihood of hedging by 10.7% (calculated as $1.8(0.1)\text{f}(\text{bX})$, where f is the normal density function and bX is the value of the right hand of the equation evaluated at the means, which in our case is equal to .596). A 10.7% increase in the likelihood of hedging is economically significant.

For the financially unconstrained firms, we find mixed results. The sensitivity of hedging to cash flow is significantly different from zero when the KZ Index is the measure of financial constraints. However, when Size and Payout are used as measures of financial constraints, the coefficients on the cash flow variable are not significantly different from zero.

Interestingly, the pattern of our results on the sensitivity of hedging to cash flow mirrors the pattern of results found in the literature on the sensitivity of capital investment to cash flow. When using a low payout ratio to identify financially constrained firms, Fazzari et al. (1988) find that constrained firms have investments activities that are more sensitive to cash flows than the unconstrained firms. We find the same pattern for the sensitivity of hedging to cash flow when using a low payout ratio or small firm size to identify financially constrained firms. However, when the KZ index is used to identify financially constrained firms, the responsiveness of investment to cash flow is greater for financially unconstrained firms than for constrained ones (Kaplan and Zingales (1997)). In our case, when constrained firms are identified with the KZ Index, we find that the sensitivity of hedging to cash flow for unconstrained firms is at least as big as the sensitivity of hedging to cash flow for financially unconstrained firms.

One interpretation of the pattern of results for the sensitivity of hedging to cash flow is that hedging decisions are like capital investment decisions. To begin a hedging operation, a firm must invest in human and physical capital with the expectation that the benefits of hedging would accrue over time.

4.2 Sensitivity of Cash Holdings to Hedging

In both the 2SLS approach and in the treatment effects model, we find a positive and significant coefficient on the hedging variable in the cash holdings equation for financially constrained firms. For the unconstrained firms, neither the estimated coefficient on the Hedges variable in the first equation nor the estimated coefficient on the ΔCH variable in the second equation is significantly differently from zero in any of the specifications.

4.3 Other Determinants of Cash Holdings and Hedging

Other results with respect to the determinants of either the change in cash holdings or the hedging activity are generally supportive of the theory leading to their inclusion in our empirical model as described in sub-section 3.4. As for the determinants of cash holdings (other than cash flows), we find a negative relationship (as expected) between investment opportunities and cash holdings. In all cases, no matter if financially constrained or unconstrained, firms save less cash if they have high expenditures, acquisitions, and change in net working capital. In the few specifications where the coefficient on firm size is statistically significant, we find that it is negatively associated with cash holdings, indicating that smaller firms save more cash (contrary to the evidence from Almeida et al. (2004) and Denis and Sibilkov (2010)). One explanation is that smaller firms are more financially constrained, all else equal.

Regarding the other determinants of firm’s hedging, we find that foreign currency risk exposure (as proxied by the ratio of foreign sales to total sales) is always positively and significantly related to the likelihood of hedging, regardless of whether the firm is financially constrained or not. The research and development expense variable is also positively and significantly related to hedging, in agreement with the idea that firms with intangible assets tend to hedge more. Our results show little support for managerial incentives as determinants of hedging (Tufano (1996)): in some specifications, we find a negative relationship with stock options awarded to the CEO (significant at the 5% level), and a positive relationship with restricted stock awarded to the CEO.

The coefficient on the Inverse Mills ratio (lambda) suggests that the self-selection bias is significant in all cases for financially constrained firms. Findings are robust for both cash holdings defined as the ratio of Cash and Short-Term Investments to Total Assets, as well as the ratio of Cash and Short-Term Investments to Net Assets, although only results using the former definition are reported. Results obtained by including year fixed effects in the two stage least squares (2SLS) are also robust.

4.4 Robustness Check

Although in our estimation we use a panel dataset, most of the firms (93.4%) in our sample do not initiate a new hedging program and neither do they drop their existing program (i.e. there is not much variation for a given firm over time in the hedging variable). Thus, the evidence regarding the likelihood of hedging is likely cross-sectional in nature.

We provide additional evidence on this issue by looking at the cross-section of firms in our sample that do not change their hedging behavior (e.g. the hedging variable is always either 0 or 1). We average variable values for all available years for each firm (297 firms). We then use the cross-section of firms with variables obtained this way to run the same regressions as before.

A summary of the coefficient estimates and p-values on the cash flow variable for the various specifications is found in Table 6. The results indicate that for all measures of financial constraints, hedging is positively related to cash flow for financially constrained firms. For unconstrained firms, the sensitivity of hedging to cash flow follows the pattern described above, i.e., using SIZE or PAYOUT to identify financially constrained firms, the unconstrained firms do not exhibit a positive sensitivity of hedging to cash flow, but using the KZ INDEX to identify financially constrained firms, the unconstrained firms to exhibit a positive sensitivity of hedging to cash flow.

5. Conclusion

We examine the determination of cash holdings and hedging, and their relation with cash flow. Our results confirm the existing evidence that firms that are likely to be financially constrained exhibit a positive sensitivity of cash holdings to cash flows. On the other hand, firms that are financially unconstrained do not consistently save cash when cash flows are higher. More importantly, we find a positive sensitivity of hedging to cash flows for constrained firms and, depending on the measures of financial constraints, for unconstrained firms as well. This result indicates the importance of available funding resources for a firm's hedging activities. The mixed results for unconstrained firms are consistent with the conflicting empirical evidence from the literature on the sensitivity of capital investment to cash flow. Indeed, we find that the relation between the likelihood of hedging and cash flow mirrors the relation between capital investments and cash flow.

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Appendix 1 – The Model

Decisions are made at time 0 and 1 and the payoffs are realized at time 2. The discount rate is zero. The funds invested at time 0 (I_0) equal the exogenous cash flows (C_0), plus the funds raised from bonds (B_0), less the cash saved for next period (R_0), less the cost of hedging (εH_0), where H_0 is the size (notional principle) of the hedging position and ε is the cost per dollar:

$$I_0 = C_0 + B_0 - R_0 - \varepsilon|H_0|.$$

At time 1, the firm invests the realized cash flows from previous investment decisions (C_1), the cash saved from the previous period less the cost of holding the cash ($(1-\rho)C_0$), plus the funds raised from bonds, B_1, plus the payoff from the hedging position, $H_0(p_1 - E(p_1))$:

$$I_1 = C_1 + (1-\rho)R_0 + B_1 + H_0[p_1 - E(p_1)].$$

Borrowing is limited to a proportion k of the investment, so that $B_0 = kI_0$ and $B_1 = kI_1$. Substituting into the expressions above, we find

$$I_0 = (1/\gamma)\,[C_0 - R_0 - \varepsilon|H_0|]$$

$$I_1 = (1/\gamma)\,[C_1 + (1-\rho)R_0 + H_0[p_1 - E(p_1)]\,], \text{ where } \gamma = 1\text{-}k$$

Investment at time 0 and time 1 generates net cash flows at time 2 equal to $F(I_0)$ and $G(I_1)$, respectively, where $F' > 0$, $F''<0$, $G'>0$, $G'' < 0$. The manager's problem is to choose R_0 and H_0 to maximize the expected net cash flow at time 2:

$$V = F\{1/\gamma[C_0 - R_0 - |H_0|\varepsilon\,]\} + E\,G\left\{\frac{1}{\gamma}[C_1 + (1-\rho)R_0 + H_0[p_1 - E(p_1)]\right\},$$

where $0<\varepsilon<1$ is the cost per dollar of the forward position. We assume that C_1 and p_1 are negatively correlated, so that a long forward position ($H>0$) would hedge the risk associated with C_1.

First Order Conditions:

R_0: $$0 = F'(I_0)\left(\frac{-1}{\gamma}\right) + E\,G'(I_1)\left(\frac{1-\rho}{\gamma}\right)$$

Rewriting, $$F'(I_0) = (1-\rho)\,E\,G'(I_1)$$

H_0: $$0 = F'(I_0)[\,\frac{-1}{\gamma}\,\varepsilon\} + E\,\{\,G'(I_1)\frac{1}{\gamma}[p_1 - E(p_1)]\,\}$$

Rewriting, $$F'(I_0) = \frac{1}{\varepsilon}\,E\,G'(I_1)[p_1 - E(p_1)] = \frac{1}{\varepsilon}\,\mathrm{Cov}\,[\,G'(I_1)\,,\,p_1\,]$$

Thus, the first order conditions imply:

$$F'(I_0) = (1\text{-}\rho)\, E\, G'(I_1) = \frac{1}{\varepsilon}\,\mathrm{Cov}[G'(I_1), p_1]$$

We assume that the second order conditions are satisfied, i.e.:

$V_{RR} = F''(I_0)\,(1/\gamma^2) + EG''(I_1)\,(1\text{-}\rho)^2/\gamma^2 < 0$, which is satisfied if $F''<0$ and $G''<0$.

$V_{HH} = F''(I_0)\,(\varepsilon/\gamma)^2 + EG''(I_1)\,\mathrm{Var}(p_1)/\gamma^2 + \mathrm{Cov}\{ G''(I_1), [p_1 - E(p_1)]^2 \}/\gamma^2 < 0$, which is satisfied if the covariance term is negative, which we will assume.

$D = V_{RR} V_{HH} - V_{RH}^2 > 0$, where $V_{RH} = F''(I_0)\,(\varepsilon/\gamma^2) + \mathrm{Cov}[G''(I_1), p_1]\,(1\text{-}\rho)/\gamma^2$

Sufficient conditions for D to be positive are $\mathrm{Cov}[G''(I_1),p_1] > 0$ and $\mathrm{Cov}[G''(I_1),p_1]\,(1\text{-}\rho)<|2F''(I_0)\varepsilon|$.

Differentiate the first order conditions with respect to C_0:

$$0 = F''(I_0)\,\frac{-1}{\gamma^2}\left(1 - \frac{dR_0}{dC_0} - \varepsilon\,\frac{d|H_0|}{dC_0}\right)$$
$$+ (1\text{-}\rho)\, E\left[G''(I_1)\frac{1}{\gamma^2}\left[(1-\rho)\,\frac{dR_0}{dC_0} + \frac{dH_0}{dC_0}\,[p_1 - E(p_1)]\right]\right]$$

$$0 = F''(I_0)\,\frac{-\varepsilon}{\gamma^2}\left(1 - \frac{dR_0}{dC_0} - \varepsilon\,\frac{d|H_0|}{dC_0}\right)$$

$$+ E\left\{G''(I_1)\,\frac{1}{\gamma^2}\,[p_1 - E(p_1)]\left[(1-\rho)\,\frac{dR_0}{dC_0} + \frac{dH_0}{dC_0}\,[p_1 - E(p_1)]\right]\right\}$$

In matrix notation:

$$\begin{pmatrix} V_{RR} & V_{RH} \\ V_{RH} & V_{HH} \end{pmatrix}\begin{pmatrix} \frac{dR_0}{dC_0} \\ \frac{dH_0}{dC_0} \end{pmatrix} = \begin{pmatrix} F''(I_0)/\gamma^2 \\ \varepsilon F''(I_0)/\gamma^2 \end{pmatrix}$$

Solving for the comparative statics yields

$$dR_0/dC_0 = F''(I_0)\,[\, V_{HH} - V_{RH}\,\varepsilon\,] / D\gamma^2$$

$$= F''(I_0)\,\{ EG''(I_1)\,\mathrm{Var}(p_1) + \mathrm{Cov}[G''(I_1), [p_1 - E(p_1)]^2 \}$$

$$- \varepsilon\,\mathrm{Cov}[G''(I_1),p_1](1\text{-}\rho) \} /D\gamma^2 ,$$

This is positive if the expression in brackets is negative. The first term is negative and the second term and third terms are negative by assumption to make the second order conditions hold. Therefore, $dR_0/dC_0 > 0$.

$$dH_0/dC_0 = F''(I_0) [V_{RR} \varepsilon - V_{RH}] / D\gamma^2$$

$$= F''(I_0) [EG''(I_1) (1-\rho)^2\varepsilon - Cov[G''(I_2),p_1](1-\rho)] / D\gamma^2 ,$$

This is positive if $Cov[G''(I_2),p_1]$ is non-negative, which is assumed so that the second order conditions hold. Thus, both comparative statics are positive.

Appendix 2 - Variable Definitions

ΔCH: change in cash holdings, where cash holdings is first defined as the ratio of holdings of cash and short-term investments to total assets, and second as the ratio of holdings of cash and short-term investments to net assets (total assets - cash)

$Hedges$: foreign currency hedging, a binary variable equal to 1 if the firm hedges foreign currency risk and to 0 if the firm does not hedge foreign currency risk

$CASHFLOW$: cash flow, or the ratio of earnings before extraordinary items and depreciation (minus dividends) to total assets

$Size$: natural log of total assets

Q: Tobin's Q, or the market value of assets divided by the book value of assets

$TaxRate$: marginal tax rate

$SOptions$: log of stock options

$RestSt$: log of restricted stock

$RDExpense$: log of expense with research and development

$TLCF$: log of tax loss carry forward

$FSales$: ratio of foreign sales to total sales

$Expenditures$: total capital expenditures divided by total assets

$Acquisitions$: total acquisitions divided by total assets

ΔNWC: change in net working capital, calculated as total current assets reduced by current liabilities and cash and short-term investments

$\Delta STDebt$: change in short-term debt

$KZIndex$: index of firms financial constraints, based on Kaplan and Zingales (1997) and Lamont, Polk, and Sáa-Requejo (2001)

$Payout$: payout ratio calculated as the ratio of dividends and repurchases to operating income

Table 1. Sample Description. This table presents the means for the variables used in regressions for the full sample and for each of the sub-samples of constrained or unconstrained firms, as determined by the three different measures of financial constraints used (Size, Payout, and KZ Index). Variable definitions are summarized in Appendix 2.

		Variable Used to Identify Financially Constrained Firms					
		Size		Payout		KZ Index	
	Entire Sample	Constr.	Not Constr.	Constr.	Not Constr.	Constr.	Not Constr
Hedges	0.703	0.586	0.819	0.621	0.784	0.575	0.831
ΔCH1	0.005	-0.000	0.010	0.005	0.005	0.003	0.007
ΔCH2	-0.012	-0.058	0.033	-0.031	0.007	-0.034	0.010
CASHFLOW	0.128	0.119	0.138	0.110	0.147	0.120	0.137
SIZE	7.030	5.833	8.223	6.680	7.378	5.962	8.100
Q	1.129	1.231	1.027	1.156	1.102	1.227	1.031
TaxRate	0.318	0.302	0.335	0.309	0.328	0.305	0.332
Expenditures	0.049	0.049	0.049	0.047	0.050	0.049	0.049
Acquisitions	0.028	0.028	0.028	0.029	0.027	0.033	0.023
ΔNWC	0.008	0.013	0.003	0.012	0.004	0.013	0.003
Δ StDebt	0.018	0.009	0.026	0.015	0.021	0.016	0.019
FSales	0.222	0.184	0.261	0.223	0.222	0.175	0.270
SOptions	9.130	8.093	10.165	8.542	9.716	7.759	10.504
RestSt	2.356	1.613	3.097	2.330	2.382	1.621	3.093
RDExpense	2.892	1.936	3.846	2.629	3.154	1.929	3.857
TLCF	1.481	1.248	1.713	1.720	1.243	1.375	1.588
DD	7.041	6.747	7.334	6.338	7.742	6.123	7.961
PAYOUT	0.201	0.158	0.244	0.059	0.343	0.131	0.272
KZIndex	-2905.23	-254.99	-5549.17	-863.96	-4941.65	-203.38	-5613.51
Obs	841	420	421	420	421	421	420

Table 2. Correlation between measures of Financial Constraints. This table shows the correlation between the four measures of financial constraints used: Distance to Default (DD), Size, Payout, and KZ INDEX. Variable definitions are summarized in Appendix 1.

	SIZE	PAYOUT Ratio
SIZE		
PAYOUT Ratio	0.10	
KZINDEX	-0.57	-0.12

Table 3. Estimation Results using Size as a measure for Financial Constraints. This table shows the estimated coefficients and p-values in parentheses from estimating the model using two stage least squares (2SLS) and a treatment effects regression. Results are shown separately for financially constrained firms and unconstrained firms, where the former has Size < median and the latter has Size > median. Variable definitions are listed in Appendix 2.

Panel A: Dependent Variable is the Change in Cash Holdings (Δ CH)

Sample	Constrained	Constrained	Unconstrained	Unconstrained
Estimation Method	2SLS	Treatment Effects	2SLS	Treatment Effects
Hedges	0.012* (0.10)	0.056 ** (0.02)	0.004 (0.15)	0.018 (0.16)
CASHFLOW	0.179*** (0.00)	0.161 *** (0.00)	-0.035 (0.36)	-0.047 (0.26)
Size	-0.008 (0.24)	-0.012 * (0.07)	-0.009 *** (0.01)	-0.007 ** (0.02)
Q	-0.012 (0.13)	-0.014 * (0.08)	-0.093 ** (0.04)	-0.091 * (0.07)
TaxRate	-0.037 (0.37)	-0.020 (0.58)	-0.045 (0.26)	-0.045 (0.30)
lagΔCH	-0.085 * (0.06)	-0.106 *** (0.01)	-0.038 (0.42)	-0.033 (0.52)
Expenditures	-0.546 *** (0.00)	-0.521 *** (0.00)	-0.141 ** (0.04)	-0.127 * (0.09)
Acquisitions	-0.286 *** (0.00)	-0.336 *** (0.00)	-0.295 *** (0.00)	-0.309 *** (0.00)
Δ NWC	-0.303 *** (0.00)	-0.21 *** (0.00)	-0.181 *** (0.00)	-0.153 *** (0.00)
Δ StDebt	-0.027 (0.43)	-0.000 ** (0.04)	-0.070 * (0.08)	-0.000 (0.87)
Constant	0.085 * (0.06)	0.076 ** (0.04)	0.211 *** (0.00)	0.186 *** (0.01)
Inverse Mills Ratio		-0.040 (0.01)		-0.007 (0.43)

*, **, *** indicates significance at the 10%, 5%, and 1% level.

Panel B: Dependent Variable: Likelihood of Hedging Foreign Currency Risk

Sample	Constrained	Constrained	Unconstrained	Unconstrained
Estimation method	2SLS	Treatment Effects	2SLS	Treatment Effects
Δ CH	-1.688		0.489	
	(0.41)		(0.90)	
CASHFLOW	1.761 **	1.602 **	1.922	1.878
	(0.03)	(0.04)	(0.17)	(0.16)
Size	0.492 ***	0.502 ***	0.186	0.182
	(0.00)	(0.00)	(0.16)	(0.16)
Q	0.111	0.141	-3.060 *	-3.145 *
	(0.50)	(0.38)	(0.09)	(0.08)
FSales	2.199 ***	2.119 ***	1.467 ***	1.462 ***
	(0.00)	(0.00)	(0.00)	(0.00)
SOptions	-0.019	-0.020	0.008	0.008
	(0.21)	(0.17)	(0.65)	(0.66)
RestSt	0.012	0.013	-0.017	-0.017
	(0.48)	(0.45)	(0.24)	(0.24)
RDExpense	0.036	0.039	0.258 ***	0.260 ***
	(0.48)	(0.43)	(0.00)	(0.00)
TLCF	-0.013	-0.016	0.019	0.019
	(0.72)	(0.68)	(0.62)	(0.63)
Constant	-3.270 ***	-3.328 ***	1.112	1.238
	(0.00)	(0.00)	(0.66)	(0.61)

*, **, *** indicates significance at the 10%, 5%, and 1% level.

Table 4. Estimation Results using Payout as a measure for Financial Constraints. This table shows the estimated coefficients and p-values from estimating the model using two stage least squares (2SLS) and a treatment effects regression. Results are shown separately for financially constrained firms and unconstrained firms, where the former has Payout < median and the latter has Payout > median. Variable definitions are listed in Appendix 2.

Panel A: Dependent Variable is the Change in Cash Holdings (Δ CH)

Sample	Constrained	Constrained	Unconstrained	Unconstrained
Estimation Method	2SLS	Treatment Effects	2SLS	Treatment Effects
Hedges	0.010 *	0.047 ***	0.001	-0.004
	(0.08)	(0.01)	(0.85)	(0.82)
CASHFLOW	0.188 ***	0.171 ***	0.002	-0.001
	(0.00)	(0.00)	(0.96)	(0.99)
Size	-0.004	-0.007 *	-0.001	0.000
	(0.35)	(0.08)	(0.84)	(0.85)
Q	-0.014	-0.015 *	-0.019	-0.020
	(0.15)	(0.07)	(0.16)	(0.14)
TaxRate	-0.047	-0.016	0.016	0.013
	(0.33)	(0.67)	(0.70)	(0.75)
lagΔCH	-0.096 **	-0.112 ***	-0.016	-0.013
	(0.05)	(0.00)	(0.78)	(0.81)
Expenditures	-0.420 ***	-0.420 ***	-0.217 **	-0.229 ***
	(0.00)	(0.00)	(0.02)	(0.01)
Acquisitions	-0.272 ***	-0.282 ***	-0.327 ***	-0.346 ***
	(0.00)	(0.00)	(0.00)	(0.00)
Δ NWC	-0.246 ***	-0.192 ***	-0.299 ***	-0.263 ***
	(0.00)	(0.00)	(0.00)	(0.00)
Δ StDebt	-0.023	0.000	-0.105 **	-0.000
	(0.54)	(0.33)	(0.04)	(0.25)
Constant	0.069 **	0.053 **	0.047	0.045
	(0.05)	(0.05)	(0.14)	(0.11)
Inverse Mills Ratio		0.035 ***		0.006
		(0.00)		(0.57)

*, **, *** indicates significance at the 10%, 5%, and 1% level.

Panel B: Dependent Variable is the Likelihood of Hedging Foreign Currency Risk

Sample	Constrained	Constrained	Unconstrained	Unconstrained
Estimation Method	2SLS	Treatment Effects	2SLS	Treatment Effects
Δ CH	-2.840		3.120	
	(0.18)		(0.28)	
CASHFLOW	1.805 ***	1.499 *	1.902	1.749
	(0.01)	(0.06)	(0.14)	(0.16)
Size	0.285 ***	0.290 ***	0.136 *	0.135 **
	(0.00)	(0.00)	(0.07)	(0.05)
Q	0.025	0.077	-0.316	-0.383
	(0.88)	(0.66)	(0.42)	(0.29)
FSales	2.708 ***	2.586 ***	0.961 **	0.965 **
	(0.00)	(0.00)	(0.03)	(0.02)
SOptions	-0.031 **	-0.032 **	0.019	0.016
	(0.02)	(0.03)	(0.31)	(0.36)
RestSt	-0.008	-0.007	0.011	0.011
	(0.56)	(0.64)	(0.55)	(0.53)
RDExpense	0.068 *	0.065	0.258 ***	0.257 ***
	(0.07)	(0.13)	(0.00)	(0.00)
TLCF	0.048	0.044	0.001	-0.001
	(0.11)	(0.20)	(0.98)	(0.99)
Constant	-2.264 ***	-2.288 ***	-1.114	-0.966
	(0.00)	(0.00)	(0.17)	(0.19)

*, **, *** indicates significance at the 10%, 5%, and 1% level.

Table 5. Estimation Results using KZIndex as a measure for Financial Constraints. This table shows the estimated coefficients and p-values from estimating the model using two stage least squares (2SLS) and a treatment effects regression. Results are shown separately for financially constrained firms and unconstrained firms, where the former has KZIndex < median and the latter has KZIndex > median. Variable definitions are listed in Appendix 2.

Panel A: Dependent Variable is the Change in Cash Holdings (Δ CH)

Sample	Constrained	Constrained	Unconstrained	Unconstrained
Estimation Method	2SLS	Treatment Effects	2SLS	Treatment Effects
Hedges	0.015 **	0.061 ***	-0.001	0.001
	(0.02)	(0.01)	(0.74)	(0.96)
CASHFLOW	0.157 ***	0.144 ***	0.006	-0.010
	(0.00)	(0.00)	(0.87)	(0.80)
Size	-0.002	-0.005	0.002	0.003
	(0.72)	(0.33)	(0.38)	(0.28)
Q	-0.012	-0.014 *	0.057	0.061
	(0.15)	(0.09)	(0.25)	(0.22)
TaxRate	-0.049	-0.020	0.011	0.015
	(0.25)	(0.59)	(0.78)	(0.71)
lagΔCH	-0.110 **	-0.139 ***	-0.011	-0.016
	(0.03)	(0.00)	(0.78)	(0.70)
Expenditures	-0.541 ***	-0.511 ***	-0.088	-0.091
	(0.00)	(0.00)	(0.21)	(0.19)
Acquisitions	-0.343 ***	-0.372 ***	-0.254 ***	-0.274 ***
	(0.00)	(0.00)	(0.00)	(0.00)
Δ NWC	-0.251 ***	-0.190 ***	-0.322 ***	-0.269 ***
	(0.00)	(0.00)	(0.00)	(0.00)
Δ StDebt	-0.016	0.000	-0.105 ***	-0.000
	(0.66)	(0.18)	(0.01)	(0.13)
Constant	0.062	0.044	-0.062	-0.072
	(0.11)	(0.18)	(0.33)	(0.28)
Inverse Mills Ratio		-0.042 ***		-0.001
		(0.00)		(0.94)

*, **, *** indicates significance at the 10%, 5%, and 1% level.

Panel B: Dependent Variable is the Likelihood of Hedging Foreign Currency Risk

Sample	Constrained	Constrained	Unconstrained	Unconstrained
Estimation Method	2SLS	Treatment Effects	2SLS	Treatment Effects
Δ CH	-0.751		2.896	
	(0.71)		(0.41)	
CASHFLOW	2.120 ***	2.048 ***	2.629 **	2.550 **
	(0.01)	(0.01)	(0.02)	(0.03)
Size	0.368 ***	0.370 ***	-0.027	-0.015
	(0.00)	(0.00)	(0.81)	(0.89)
Q	0.102	0.115	-4.990 ***	-4.797 ***
	(0.54)	(0.47)	(0.01)	(0.01)
FSales	2.250 ***	2.215 ***	1.278 ***	1.291 ***
	(0.00)	(0.00)	(0.00)	(0.00)
SOptions	-0.012	-0.012	0.004	0.001
	(0.40)	(0.38)	(0.85)	(0.97)
RestSt	0.019	0.019	-0.016	-0.018
	(0.26)	(0.26)	(0.25)	(0.20)
RDExpense	0.085 *	0.084 *	0.239 ***	0.238 ***
	(0.09)	(0.08)	(0.00)	(0.00)
TLCF	-0.020	-0.021	0.027	0.027
	(0.59)	(0.56)	(0.49)	(0.49)
Constant	-2.800 ***	-2.808 ***	4.874 **	4.646 *
	(0.00)	(0.00)	(0.04)	(0.06)

*, **, *** indicates significance at the 10%, 5%, and 1% level.

Table 6. Coefficient estimates and p-values in parentheses on the CASHFLOW variable from cross-sectional regressions for financially constrained and unconstrained firms estimated under different empirical models (2SLS and Treatment Effects) and with different methods of identifying financially constrained and unconstrained firms (Size, Payout, KZIndex). The sample only includes firms that maintain the same hedging status through the sample period. Variable values are within-firm averages during the sample period.

		Constrained		Unconstrained	
Measure of Financial Constraints	Dependent Variable	2SLS	Treatment Effects	2SLS	Treatment Effects
Size	Δ CH	0 .081	0.120 *	-0.139	-0.151 ***
		(0.22)	(0.06)	(0.34)	(0.01)
	Hedges	5.357 **	4.079 **	6.325	5.586 **
		(0.02)	(0.02)	(0.38)	(0.05)
Payout	Δ CH	-0.051	0.067	0.034	0.026
		(0.71)	(0.35)	(0.74)	(0.52)
	Hedges	4.412 *	4.480 *	-0.866	-1.006
		(0.05)	(0.01)	(0.83)	(0.71)
KZ Index	Δ CH	0.025 *	0.132 **	0.073	-0.002
		(0.07)	(0.02)	(0.91)	(0.98)
	Hedges	4.871 *	6.167 ***	3.867 **	3.868 **
		(0.10)	(0.01)	(0.04)	(0.03)

*, **, *** indicates significance at the 10%, 5%, and 1% level.