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On the negative relation between investment-cash flow sensitivities and cash-cash flow sensitivities*

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ABSTRACT

We predict and find empirical support for a negative relation between the firm's investment-cash flow sensitivity and cash-cash flow sensitivity, two measures suggested to capture the concept of financing constraints. This negative relation on the firm-level stems from the fact that both *investments* and the *cash account* are uses of funds competing for limited available cash flows. Additionally, we find that the investment-cash flow sensitivity is a better predictor for the firm's constraint-status than the cash-cash flow sensitivity for a longitudinal sample of 1,233 U.S.-based listed firms using an evaluative framework based upon *ex-post* evaluation of the firm-varying sensitivities.

Key-words: financing constraints, investment-cash flow sensitivities, cash-cash flow sensitivities, firm-varying sensitivities

JEL-classification: G30, G31

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Can financing frictions be accurately measured? A large and growing body of literature aims to develop an adequate proxy to measure the degree of financing constraints a firm might face. Most studies in the field estimate investment-cash flow sensitivities (ICFS) defined as the investment response due to a change in cash flow. This metric should be larger for constrained firms because these firms have only limited access to external sources, and therefore should invest at the pace of their retained earnings (Fazzari, Hubbard and Petersen, 1988, FHP88 from hereinafter). A large number of studies (Hoshi et al., 1991; Bond et al., 2003; Bhagat et al., 2005; Rauh, 2006) confirm that the ICFS-metric is indeed higher for categories of firms more likely to suffer from market imperfections (*small firms*, *low dividend-paying* firms, firms without *debt and/or commercial paper ratings*, etc.).

However, a number of recent studies find contradicting empirical evidence and suggest that a significant ICFS might be driven by increased investment opportunities or by endogeneity-bias in the underlying investment equation (Kaplan and Zingales, 1997, KZ97 from hereinafter; Kadapakkam et al., 1998; Cleary, 1999). These studies usually emphasize that a significant ICFS might originate from a spurious cash flow effect arising from cash flow capturing investment opportunities rather than signalling financing frictions. Overall, there seems to be a growing disagreement in the literature with a number of very recent contributions that either support the performance of ICFS-metric (Guariglia and Carpenter, 2008; Guariglia, 2008; Islam and Mozumdar, 2007; Agca and Mozumdar, 2008) or contradict the performance of the ICFS-metric in terms of capturing financing constraints (Erickson and Whited, 2000; Cummins et al., 2006; Lyandres, 2007; Wei and Zhang, 2008).

As a response to this growing controversy, Almeida et al. (2004) and a number of subsequent studies such as Lin (2007), Khurana et al. (2006) and Han and Qiu (2007) suggest to focus on cash-cash flow sensitivities (CCFS) as a metric to capture financing constraints. This metric is defined as the change in the cash account due to change in cash flow and should be higher for constrained firms, since these firms should have the tendency to buffer cash in order to compensate for future fluctuations in net worth. Almeida et al. (2004) argue that the focus on a *financial* variable rather than on a *real* variable should make this metric less susceptible to debate in comparison to the ICFS-metric, because in the underlying *cash*-equation there is no need to control for unknown future investment opportunities. Indeed, this metric seems to avoid the whole discussion whether or not the ICFS-effect reflects a spurious investment opportunities-effect rather than signalling financing frictions.

In the existing literature, both metrics seems to exist separately and which metric is being used seems to be dependent upon choice of the researcher. The aim of this paper is twofold. First, we argue that both metrics are fundamentally linked on the firm-level. This relation is embedded in the original two-period model of Almeida et al. (2004) and stems from the fact that both *investments* and the *cash account* can be considered alternative uses of funds competing for limited available cash flows. As a result a firm that displays a high ICFS over the observed sample period will necessarily display a low CCFS and vice versa, ceteris paribus. As far as we know this is the first study to analyze both theoretically and empirically the firm-level link between these two measures, currently considered separate measures to capture the same economic phenomenon. We believe that this negative relation between the two metrics is important given the continuous and growing disagreement on the ICFS-metric, and the recent shift in attention towards estimating the CCFS-metric to capture financing constraints.

Secondly, we analyze both metrics in their ability to capture constraints by regressing the firm-specific sensitivities on a number of observables that have been shown to vary with the constraints-status of the firm. This approach is very much in line with the ex-post evaluative framework suggested in Hovakimian (2009), Hovakimian and Hovakimian (2009) and D'Espallier et al. (2008). The results show that the firm-level ICFS is significantly related to a wide number of observable measures of financing constraints. For the firm-level CCFS, we find no relation with any of these observable measures of financing constraints, suggesting that the firm's cash policy is a poor predictor of the firm's constraints-status.

This poor performance of the CCFS-metric alongside its negative relation with the ICFS-metric seriously questions the recent shift in attention towards measuring cash-cash flow sensitivities in order to capture the firm's financing constraints. This result is in line with the recent findings by Riddick and Whited (forthcoming) who argue that the firm's cash policy is driven by income shocks and taxation issues rather than by the cost of external funds.

This paper is organised as follows. In the next section, we discuss some of the most recent literature on both metrics with specific attention to the disagreement on the ICFS-metric and the seeming benefits of the CCFS-metric in addressing these issues. In the second section, we revisit the theoretical model of Almeida et al. (2004) in order to derive the negative relation on the firm-level between ICFS and CCFS. Section 4 summarizes the main empirical findings based upon a large longitudinal sample of U.S.-based listed firms. Finally, in section 5 we conclude and discuss potential implications, limitations and suggestions for further research.

I. Measuring financing constraints

In their seminal paper, FHP88 investigate different cash flow-augmented investment models to estimate the ICFS as a proxy for financing constraints. The ICFS, which is the coefficient of cash flow in the underlying investment equation, measures the investment response due to a change in cash flow and is predicted to be higher for financially constrained firms. This metric is to a certain extent intuitively appealing because firms suffering from capital market imperfections depend mainly on their internal funds and therefore will invest at the pace of their retained earnings. Consequently, the investment rate of constrained firms will fluctuate with the availability of internally generated cash flows which leads to a large correspondence between cash flow and investment.

Many studies provide empirical support for the FHP88-results by showing that the ICFS is higher for firms that have a high 'susceptibility' to capital market imperfections and vice versa. For instance, Gilchrist and Himmelberg (1995) and Carpenter and Petersen (2002) find a higher ICFS for *smaller* firms, Hoshi et al. (1991) and Deloof (1998) find a lower ICFS for firms with a *close bank-affiliation*, Bond et al. (2003) and Islam and Mozumdar (2007) find a higher ICFS for firms operating in a competitive, *market-based* environment. Bhagat et al. (2005) find a higher ICFS for firms with *fewer tangible* assets. These studies seem to confirm that the ICFS is higher for firms more subject to capital market imperfections.

On the other hand, a number of studies have found opposite empirical results. For instance, KZ97 analyze the subset of most financially constrained from the FHP88-sample, i.e. the ones with the lowest *dividend-payout ratio*, and find a lower ICFS for this group. Similarly, Cleary (1999) finds a lower ICFS for firms more subject to capital market imperfections using a constructed *Z-score index,* and Kadapakkam et al. (1998) finds a lower ICFS for *smaller* firms using a large international dataset covering 6 OECD countries. These studies have fuelled the debate and seriously challenge whether the ICFS can be considered an accurate proxy for financing constraints.

As argued by Whited (1992), Gomes (2001), Alti (2003), Cummins et al. (2006) among others, one important caveat in the analysis that might explain the contradictory findings in the literature is that cash flow might convey information about the firm's future investment opportunities. When this is the case, a significant ICFS-effect might be observed that reflects increased investment opportunities rather than signalling financing frictions. In other words, the observed relation between cash flow and investment might be a spurious effect resulting from the inability to control for investment opportunities in the underlying investment equation.

Traditionally, the Q -investment paradigm is being used that adds a proxy for Tobin's Q (usually proxied by the firm's market value over book value) in the investment equation in order to control for investment opportunities. However, many studies emphasize that Q has often low explanatory power in the reduced-form investment equation and therefore might be a poor proxy for investment opportunities (Gilchrist and Himmelberg, 1995; Goergen and Renneboog, 2001; Cooper and Ejarque, 2003; Bond et al., 2003). Therefore, some recent studies experiment with new and improved proxies for investment opportunities. For instance, Gilchrist and Himmelberg (1995) use a variable 'Fundamental Q' which is the expected value of Marginal Q estimated from a set of VAR forecasting equations. Erickson and Whited (2000) estimate Marginal Q directly using measurement error-consistent GMM estimates. Cummins et al. (2006) and Almeida and Campello (2007) use analyst's forecasts as instruments for estimating Q. Finally, Guariglia and Carpenter (2008) use the amount of contracted capital expenditures as an improved proxy for investment opportunities.

Despite these many efforts, there seems to be no agreement whether these improved proxies sufficiently control for investment opportunities in the underlying investment equation. For instance, while Gilchrist and Himmelberg (1995), Guariglia and Carpenter (2008) and Guariglia (2008) report that a significant excess-sensitivity pertains after successfully controlling for investment opportunities, Erickson and Whited (2000), Bond and Cummins (2001) and Cummins et al. (2006) believe that the significant ICFS effect is still primarily driven by the measurement error in Q.

The previous debate has incited many researchers to move away from estimating cash flow-augmented investment equations and focus on cash flow-augmented *cash* models. In an important paper, Almeida et al. (2004) project that the cash response due to a change in cash flow (CCFS) might be an interesting proxy to assess the degree in capital market imperfections. They project that constrained firms should display a tendency to buffer cash in order to anticipate future fluctuations in cash flow. Since constrained firms cannot depend on external sources at all times, they use cash and marketable securities as a cushion against future cash flow fluctuations. Therefore, the firm's cash response resulting from a change in cash flow i.e. cash-cash flow sensitivity might be a good proxy to measure the degree in capital market imperfections.

The main benefit of this metric is that it analyzes a 'financial' variable (*cash*), rather than a 'real' variable (*investment*), so that it cannot be argued that the results are driven by differences in investment opportunities. Almeida et al. (2004) find empirical support for this theoretical prediction by showing that the CCFS is significantly higher for groups of firms with a higher tendency for capital market imperfections (*smaller* firms, *low dividend-paying* firms, firms *without debt and commercial paper ratings*). A number of subsequent studies such as Khurana et al. (2006), Han and Qiu (2007) and Lin (2007) follow this view and find that the CCFS might be a good predictor for the firm's constraints-status using different ex-ante classification criteria. Along the same lines, Faulkender and Wang (2006) argue that an extra dollar of cash is more valuable to shareholders of financially constrained firms.

II. The Almeida et al. (2004)-model revisited

The previous discussion shows that there is substantial debate on the usefulness of the ICFS-metric, even in the most recent literature. At the same time, some recent studies move away from estimating ICFS and choose to focus upon the CCFS-metric to measure the degree of capital market imperfections. Both strands of literature seem to develop separately and no studies of which we know have pointed out that there is a fundamental firm-level relation between both metrics. In this section, we argue that the ICFS and the CCFS are negatively linked on the firm-level using the two-period theoretical model by Almeida et al. (2004).

A. Modelling Set-up

Almeida et al. (2004) develop a two-period model in which there are three dates 0, 1 and 2. At date 0, the firm has ongoing operations that generate cash flow c_0. At date 1, these operations yield payoff c_1^H or c_1^L depending on the business conditions that are either high (H) or low (L) with probabilities p and *1-p*, respectively. The firm can initiate a project I_0 at date 0 that pays off $F(I_0)$ at date 2 and initiate a project I_1 at date 1 that generates payoff $G(I_0)$ at date 2. Both production functions are concave and continuously differentiable. Investments can be liquidated at date 2 but only at a fraction of the original investment $q(I_0 + I_1)$. Therefore, total cash flows from both investment projects I_0 and I_1 can be written as $f(I_0) = F(I_0) + qI_0$ and $g(I_1) = G(I_1) + qI_1$. The firm can decide to transfer an amount of cash C from one period to another. Finally, the firm can extract external funds by pledging collateral up to a fraction of its total liquidation value which is given by $(1-\tau)qI$ where τ is a parameter that represents the risk-premium demanded by external investors. For high levels of τ, the firm could become financially constrained because it is restricted from extracting external funds in the market.

B. Value-maximization

In this set-up each value-maximizing firm will maximize the sum of the discounted value of its future dividend stream subject to a number of budget and financial constraints as follows:

$$\max_{C,h,I} (d_0 + pd_1^H + (1-p)d_1^L + pd_2^H + (1-p)d_2^L) \quad (1)$$

Subject to:

$$d_0 = c_0 + B_0 - I_0 - C \geq 0 \quad (2)$$

$$d_1^S = c_1^S + h^S + B_1^S - I_1^S + C \geq 0 \quad \text{for } S = H, L \quad (3)$$

$$d_2^S = f(I_0^S) + g(I_1^S) - B_0 - B_1^S \quad \text{for } S = H, L \quad (4)$$

$$B_0 \leq (1-\tau)qI_0 \quad (5)$$

$$B_1^S \leq (1-\tau)qI_1^S \quad \text{for } S = H, L \quad (6)$$

$$ph^H + (1-p)h^L = 0 \quad (7)$$

Equation (1) expresses the value of the firm as the present value of the future dividend stream which needs to be maximized, where d_0, d_1 and d_2 are dividends in periods 0, 1 and 2, respectively. Equations (2), (3) and (4) model the dividends at date 0, 1 and 2 in different states *S* that can either be low (*L*) or high (*H*). The terms B_0 and B_1 are borrowing amounts that are issued at dates 0 and 1, respectively and need to be repaid at date 2. Equations (5) and (6) reflect the borrowing amounts that can never be higher than the collateral value of new investments. Finally, equation (7) reflects a hedging-identity which signifies that the firm can perform a hedging operation in order to hedge against insecurity of the state *S* (either *H* or *L*) by taking an opposite position on for instance the futures market. The identity states that combined payoff from both spot and futures markets on the hedging amount *h* should equal zero.

Almeida et al. (2004) show that in case of financing frictions, the firm cannot undertake its first-best investment level and borrowing capacity will be exhausted at dates 0 and 1. Additionally, no dividends will be paid at dates 0 and 1. Using these facts, the firm's maximization problem can be written as:

$$\max_{C} \; f\left(\frac{c_0-C}{1-q+\tau q}\right)+pg\left(\frac{c_1^H-\left(\frac{1-p}{p}\right)h^L+C}{1-q+\tau q}\right)+(1-p)g\left(\frac{c_1^L+h^L+C}{1-q+\tau q}\right) \quad (8)$$

Writing the first-order condition and solving for C, the optimal cash policy C* is determined by:

$$f'\left(\frac{c_0-C^*}{1-q+\tau q}\right)=g'\left(\frac{E_0[c_1]+C^*}{1-q+\tau q}\right) \quad (9)$$

Equation (9) represents that in equilibrium the firm's *marginal costs* of holding cash will be offset exactly by the firm's *marginal benefits* of holding cash. The left-hand side represents the marginal cost of holding cash that originates from sacrificing current valuable investment projects at the expense of a higher cash transfer to the next period. The right-hand side of the equation represents the marginal benefit of holding cash that originates from the firm's ability to relax the borrowing constraint in the future by its increased cash holdings. In equilibrium the marginal cost of an additional dollar cash transfer will be offset exactly by the marginal benefit of an additional dollar cash transfer so that equation (9) can also be written as:

$$\left(\frac{\partial \text{ value}}{\partial C}\right) = \left(\frac{\partial \text{ cost}}{\partial C}\right) \qquad (10)$$

where the right-hand side is the marginal benefit of holding cash defined as the change in firm-value due to a change in cash, and the left-hand side is the marginal cost of holding cash defined as the change in costs due to a change in cash.

C. Implications for optimal investment and cash policy

Almeida et al. (2004) state that the main implication from their model is that the constrained firm has a clear incentive to transfer an optimal amount of cash C^* from one period to the next, thereby creating a propensity to save cash out of its cash flows. Put differently, each firm will balance marginal *costs* of holding cash with marginal *benefits* of holding cash so that an optimal amount of cash will be transferred into the next period. As a result, the constrained firm will display positive cash-cash flow sensitivity, whereas for the unconstrained firms we would expect no such relation to exist. This can be written as follows:

$$\left(\frac{\partial \text{ value}}{\partial C}\right) = \left(\frac{\partial \text{ cost}}{\partial C}\right) \xrightarrow{yields} C^* \tag{11}$$

$$\xrightarrow{yields} CCFS > 0$$

While we fully agree with these implications, we believe that this is only part of the story. The magnitude of the optimal amount of cash C^* fully depends upon the firm's current investment opportunities. When the firm's current investment opportunities are low, the marginal cost of holding cash (originating from sacrificing current opportunities) will also be low and the marginal benefit of holding cash (originating from relaxing potential future constraints) will be high. As a result, a larger amount of cash will be transferred into the next period so that C^* is high. Adversely, when the firm's current investment opportunities are high, the marginal cost of holding cash will also be high and the marginal benefit of holding cash will be low. Consequently, a smaller amount of cash will be transferred into the next period so that C^* is low.

In other words, the marginal cost of holding cash and the marginal benefit of holding cash are a direct function of the firm's current investment opportunities which has a direct influence on the optimal amount of cash C^* that will be transferred into the next period. This can be written as follows:

$$\left(\frac{\partial \text{ value}}{\partial C}\right) = f(\text{inv.opp}) \Rightarrow \frac{\partial}{\partial \text{ inv.opp}}\left(\frac{\partial \text{ value}}{\partial C}\right) < 0 \tag{12}$$

$$\left(\frac{\partial \text{ cost}}{\partial C}\right) = f(\text{inv.opp}) \Rightarrow \frac{\partial}{\partial \text{ inv.opp}}\left(\frac{\partial \text{ cost}}{\partial C}\right) > 0 \tag{13}$$

$$\xrightarrow{yields} C^* = f\ (\text{inv.opp}) \tag{14}$$

Put differently, although the model predicts the *existence* of an optimal amount of cash *C** that gives rise to a significant CCFS, the model is unable to predict the *magnitude* of the amount *C**, which clearly depends upon the level of current investment opportunities. Low current investment opportunities indicate a low marginal cost of holding cash which leads to a larger amount of *C** being transferred into the next period. High current investment opportunities indicate a higher marginal cost of holding cash which leads to a lower amount of *C** being transferred.

Furthermore, the existence of an optimal amount of cash *C** leads to an optimal amount of investment *I** inversely proportional to *C**, because the firm's *cash account* and *investments* are two opposite uses of funds, competing for the firm's limited available cash flow, holding constant other uses of funds (such as dividends, perks etc.[1]). A firm that transfers a high amount of cash *C** into the next period, will have fewer funds at its disposal for direct investment which leads to a lower *I**. Vice versa, a firm that transfers a low amount of cash *C** into the next period, will have more funds available for investment *I**, ceteris paribus.

[1] The major other use of funds besides cash and investments is dividends, but dividends are often fixed over time, because shareholders prefer a steady dividend-flow. Therefore, it can be reasonably assumed that the investments and the cash account are two major uses of funds holding competing for limited available cash flows.

This means that the Almeida et al. (2004)-model does not only predict an optimal amount of cash C^*, indicating a significant CCFS, but also predicts an optimal amount of investment I^*, which might lead to a significant ICFS, depending upon the current investment opportunities. At each date, a firm will balance investments and cash, depending on their marginal contribution to the future dividend stream. Firms with many valuable investment opportunities today, have no reasons to postpone current investment opportunities at the benefit of increased cash transfer and will put their limited cash flows in investments. These firms will operate under a high ICFS at the expense of less cash transfer to the next period i.e. a lower CCFS. On the other hand, firms with few valuable current investment opportunities today, will have a greater incentive to buffer cash. These firms will operate under a high CCFS at the expense of lesser current investments i.e. a lower ICFS. This can be written as follows:

$$\left(\frac{\partial \text{ value}}{\partial C}\right) = \left(\frac{\partial \text{ cost}}{\partial C}\right)$$

$$\xrightarrow{yields} C^* = f\ (\text{inv.opp}) \Rightarrow CCFS = f\ (\text{inv.opp}) > 0 \quad (15)$$

$$\xrightarrow{yields} I^* = f\ (\text{inv.opp}) \Rightarrow ICFS = f\ (\text{inv.opp}) > 0 \quad (16)$$

Note that the model does not prevent a firm from having both positive ICFS and CCFS over the observed sample period since investment opportunities are likely to change over time. It is perfectly possible that the firm will put most of its cash flows on investments when current investment opportunities are high, and decides to put its cash flow on the cash accounts when investment opportunities decrease. Therefore, it is possible that a firm exhibits both positive

ICFS and positive CCFS over the observed sample period. However, the *level* of ICFS and the *level* of CCFS will generally be inversely proportional since cash and investments are competing uses of funds. Therefore, a firm that puts most of its cash flow on the cash account will have fewer funds available to invest and vice versa. In other words, over the observed sample period, a firm will have either put most of its cash flow on investments (at the expense of fewer funds for the cash account) or either on the cash account (at the expense of fewer funds for direct investments). In conclusion, we expect a negative relation between the firm's CCFS and the firm's ICFS which is the main proposition to be tested in this paper.

III. Empirical Results

The previous discussion shows that the negative relation between the firm's ICFS and CCFS is embedded in the original two-period theoretical framework developed in Almeida et al. (2004) and originates from the fact that *investments* and the *cash account* are two rival uses of funds, competing for the firm's limited available cash flows. In this section we test this assertion empirically using a large longitudinal dataset of 1,233 U.S.-based listed manufacturing firms.

A. Data and Sample Descriptives

Annual financial data were extracted from COMPUSTAT for U.S.-based listed firms over a five-year time period from 2000-2004 (included). Firms belonging to regulated and financial industries according to their two-digit SIC-code (43XX, 48XX, 49XX, 6XXX, 9XXX) were excluded from the sample. An additional requirement for firms to enter the sample is that they do not report negative values for *market-to-book*, *total assets* or *capital stock* during the sample-period. Negative cash flow observations were excluded from the sample so that we remove firms that are in financial distress rather than facing financing frictions[2]. Investments are truncated at zero which is the standard approach in the literature.

To remove outliers, the upper and lower 1% of observations was deleted for all variables in the dataset[3]. Additionally, each variable that enters the regression equation has been 'winsorized' if its value exceeds a pre-specified cut-off value. Cut-offs were chosen in such a way that values beyond these points can reasonably be considered outliers[4]. These procedures lead to a large unbalanced data-set of 1,233 firms over 5 years which means 6,165 firm-year observations.

Table I presents summary statistics for a selection of financial variables for the sample under study. As can be seen, the median firm has around 0.48 billion dollars in total assets and has annual sales around 0.51 billion dollars. The investment rate for the median observation is around 10% and cash flow is around 21% of capital stock. The median value for Tobin's Q is 1.94, which means that the stock market values the median firm almost twice as high as the firm's book-value. Most of the firms do not pay out dividends as can be seen from the median dividend ratio of 0.00. In fact, only in 47% of the observations a positive dividend has been paid out with an average value of 5.2% of the capital stock. The median tangibility ratio is 0.56 which means that half of the fixed assets are tangible assets for the median firm. Most firms have a rather healthy cash position as can be seen from the cash ratio with a median value of 0.11, slack ratio with a median value of 0.51 and the current ratio, which is 2.03 for

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[2] This is in line with Allayannis and Mozumdar (2004) and Islam and Mozumdar (2007) who emphasize a distortionary effect of negative cash flow observations.

[3] Removal of the upper and lower percentile is standard procedure in the literature on financing constraints (Bhagat et al., 2005).

[4] Following cut-offs have been used: $(I/K)_{i,t} = \pm 2.0$; $Q_{i,t} = \pm 10.0$; $(CF/K)_{i,t} = \pm 5.0$. These cut-offs are sufficiently wide so that values beyond the cut-off points can reasonably be considered outliers.

the median firm. Sales growth was around 9% for the median firm. Coverage ratio for the median firm is around 4.62 which means that EBIT is roughly five times as high as the interest payments. Sales growth is 9% for the median firm and return on equity is around 10%.

< Insert Table I around here >

B. Firm-level sensitivities and their negative relation

As mentioned earlier, the ICFS is estimated by analyzing cash flow-augmented investment models. We use the augmented static Q model of investment with firm- and time-fixed effects. This specification is frequently used in the literature (for instance KZ97; Cleary, 1999; Alayannis and Mozumdar, 2004; Cleary, 2006; Islam and Mozumdar, 2007; among others) and can be written as:

$$(I/K)_{i,t} = \beta_0 + \beta_1 (CF/K)_{i,t} + \beta_2 Q_{i,t} + \delta_i + \eta_t + u_{i,t} \qquad (17)$$

where $(I/K)_{i,t}$ is the investment rate, $(CF/K)_{i,t}$ is the cash flow rate, $Q_{i,t}$ is Tobin's Q and firm-fixed effects (δ_i) and time-fixed effects (η_t) are added to capture all firm-specific and time-specific heterogeneity not accounted for in the model. In this specification β is the ICFS that measures the investment response due to a change in cash flow.

The CCFS is measured by analyzing cash flow-augmented cash models. We use the specification developed in the Almeida et al. (2004)[5] which regresses the change in cash on cash flow and a number of control variables as in:

$$\Delta CH/TA_{i,t} = \beta_0 + \beta_1 CF/TA_{i,t} + \beta_2 lnTA + \beta_3 Q_{i,t} + \delta_i + \eta_t + u_{i,t} \quad (18)$$

where $(\Delta CH/TA)_{i,t}$ is the change in cash and marketable securities and $(CF/K)_{i,t}$ is again the cash flow rate. In this specification, the natural logarithm of total assets is added to control for arguments of economies of scale in cash management. $Q_{i,t}$ is added because the firm's cash policy should be influenced by the attractiveness of future investment opportunities and Tobin's Q is believed to capture unobservable observation about the value of the long-term growth options available to the firm. Again δ_i and η_t represent time and firm-specific effects. The coefficient β is the CCFS that measures the cash response due to a change in cash flow.

In order to test the firm-level relation between the ICFS and the CCFS we estimate the models (17) and (18) using a varying coefficients model so that average coefficient for cash flow β is replaced by a firm-varying coefficient β_i. Consequently, the cash flow-augmented investment model and the cash flow-augmented cash model can be written respectively as:

$$(I/K)_{i,t} = \beta_0 + \beta_{1,i}(CF/K)_{i,t} + \beta_2 Q_{i,t} + \delta_i + \eta_t + u_{i,t} \quad (19)$$

$$\Delta CH/TA_{i,t} = \beta_0 + \beta_{1,i}(CF/TA)_{i,t} + \beta_2 lnTA + \beta_3 Q_{i,t} + \delta_i + \eta_t + u_{i,t} \quad (20)$$

[5] This specification is in fact the baseline-specification tested in Almeida et al. (2004). They also report an extended specification is also used that takes up a number of additional controls such as the change in net working capital, the change in short-term debt and the level of investment. For reasons of comparison with the ICFS-metric we use the baseline specification throughout this paper. However, the results have been checked for the augmented specification which usually yields similar results.

where $\beta_{1,i}$ is the firm-specific ICFS and CCFS, respectively. Varying coefficients model that involve heterogeneous slopes within a panel data context cannot be estimated using traditional estimation techniques such as fixed effects or random effects-estimation. Therefore, the Generalized Maximum Entropy estimator (GME) developed in Golan et al. (1996) will be used which is a non-parametric Bayesian estimation technique. Details about this estimation procedure can be found in a short appendix to this paper[6].

In Table II we report descriptives of the 1,233 firm-varying ICFS-estimates and CCFS-estimates in Panel A and B, respectively, and plot the kernel-density of the distribution of firm-specific sensitivities. As can be seen from Panel A, the mean ICFS is 0.30 which comes from a wide dispersion of firm-specific ICFS ranging between -0.34 and 1.10. The vast majority of the firms (97.8%) have an ICFS between 0 and 0.5 which are values very similar to what is usually found in previous literature. Only 0.5% of the firms have a negative ICFS which means that the firm has consistently invested despite negative cash flows or de-vested despite positive cash flows throughout the sample period. Around 0.8% of the firms have an ICFS greater than 1, which means that a 1% cash flow shock is associated with an investment response larger than 1%.

As can be seen from Panel B, the mean CCFS is 0.11 which is of similar magnitude than what is found in most studies that estimate values of CCFS. Again, this mean value comes from a wide dispersion of firm-varying CCFS ranging between -0.57 and 1.64. A value larger than 1 means that a 1% cash flow shock is associated with a larger than 1% shock in the cash account. As can be seen, only 0.08% of the firms have a cash response greater than 1. A

[6] An application of the GME-estimator to the literature on investment-cash flow sensitivities can be found in D'Espallier et al., (2008) and Cleary and D'Espallier (2007).

negative CCFS means that the firm has consistently drawn down on its cash reserves despite positive cash flows or has consistently increased its cash reserves despite negative cash flows. Around 8% of the firms display a negative CCFS. The table indicates that the vast majority of the firms (97.8%) have a CCFS between 0 and 0.50 which is a reasonable interval in terms of economic interpretation.

< Insert Table II around here >

In Table III we analyze the relation between the firm's ICFS and CCFS by reporting a number of summary statistics for the CCFS in discrete sub-samples with different ICFS-values. The classes correspond to the 4 quartiles in the ICFS-distribution from 'very low ICFS' (ICFS< 25^{th} percentile) to 'low ICFS (25^{th} percentile < ICFS < 50^{th} percentile), etc. As can be seen, the mean CCFS is highest in the 'very low ICFS'-class (0.127) and lowest in the 'very high ICFS-class (0.07). In Panel B, we report the Pearson's correlation coefficient and two non-parametric correlation coefficients (Spearman's rank correlation and Kendall's tau). All coefficients indicate a negative correlation between the ICFS and CCFS. Moreover, the negative correlation is always statistically significant at the 1% significance level. These results are a first univariate indication that firms who operate under a high ICFS seem to operate under a low CCFS and vice versa, which confirms the negative relation that was derived from the Almeida et al. (2004)-model.

< Insert Table III around here >

C. Evaluating ICFS and CCFS

We analyze which metric performs best in terms of capturing financing constraints by regressing the firm-specific sensitivities (both ICFS and CCFS) on a number of observables related to the firm's constraints-status. This regression analysis reveals how much of firm-level variation in sensitivity is actually caused by financing frictions and therefore provides an evaluative framework for both metrics. As has been mentioned by D'Espallier et al. (2008), Hovakimian and Hovakimian (2009) and Hovakimian (2009), an ex-post evaluative framework based upon firm-specific estimation provides a number of important benefits over the traditional empirical framework in which a sample-level (average) sensitivity is estimated for discrete sub-samples. First, the analysis avoids the practice of ex-ante classification in which firms are classified beforehand according to a single criterion that reflects a different 'susceptibility' to capital market imperfections (i.e. *size, dividend payout, debt and/or commercial paper ratings*, *tangibility*, etc.). As noted by a number of authors, it is unclear whether a single classification scheme is able to distinguish between firms that reflect a different degree of financing constraints[7] (see for instance Schiantarelli, 1995, Almeida and Campello, 2008; Hovakimian and Hovakimian, 2009). Secondly, the analysis avoids working with sample-level or aggregate estimates that might be biased due to endogeneity of the cash flow variable in the investment equation, which is also a widely known problem in estimating the parameters of the investment equation. (see for instance Bond et al., 2003, Carpenter and Petersen, 2002; Erickson and Whited, 2000, Riddick and Whited, forthcoming).

[7] For instance, Almeida et al., (2004) find that there is a somewhat positive but far from perfect correlation between the different classification schemes.

For the observable measures of financing constraints we use a wide selection of financial variables that have a clear relation with the constraints-status of the firm and a long-standing tradition in the literature. A large literature projects that financially constrained firms usually pay fewer *dividends* (FHP88 among others), are *smaller* (Carpenter and Petersen, 2002, inter alia.), have less *cash* (KZ97 inter alia), have higher *debt positions* (Moyen, 2004; Whited and Wu, 2006), have lower *growth* and lower *profitability* ratios (KZ97, Cleary, 1999). Therefore we expect a negative relation between the ICFS/CCFS and the *dividend payout ratio*, *(natural logarithm of) total assets*, *sales*, *cash ratio*, *sales growth*, *interest coverage*, *ROE* and a positive relation with *leverage* in the ex-post regression analysis. In Table IV we summarize the observable measures of financing constraints that were used as well as their expected signs in the ex-post regression.

< Insert Table IV around here >

In Table V we report the results from the ex-post regression analysis for the ICFS-metric and the CCFS-metric in Panel A and B, respectively. As can be seen from Panel A, the firm-level ICFS is significantly negatively related with the dividend *payout ratio*, *total assets*, *sales*, *cash ratio*, *sales growth*, *ROE* and *interest coverage* and positively related with the *debt ratio*. This suggests that a high ICFS is associated with fewer dividends, smaller firms (both in terms of total assets and sales), less profitable firms (both in terms of ROE and interest coverage), firms with less liquidity (both in terms of cash ratio and cash flow rate), firms with smaller growth performance and firms with higher leverage, indicating a positive link between the ICFS and the existence of financing constraints.

All variables have coefficients in line with our expectations presented in Table IV and most coefficients (sales growth is the exception) are significant at the 1% significance level. Moreover, the F-statistics indicates joint significance of the models at the 1% significance level and the R^2 adjusted indicates that a significant proportion of variation is explained by the observable measures of financing constraints. The finding seem to hold regardless of whether *size* is measured by *total assets* or *sales*, whether profitability is measured by *ROE* or *interest coverage* and whether the firm's liquidity position is measured by the *cash ratio* or the *cash flow rate* as can be seen from the different columns in the table. There seems to be a persistent relation between the ICFS and the observables related to the constraints-status of the firm. When the CCFS is added as an extra dependent variable in columns (5) and (6) the regression returns a statistically significant negative coefficient, which provides a multivariate check for the negative relation between ICFS and CCFS.

Looking at Panel B, a totally different picture emerges from the analysis. We observe no significant relation between the CCFS and any of the observable measures of financing constraints. A higher CCFS is seems unrelated to the *dividend policy*, *firm size*, *firm growth, liquidity position* and *profitability* position. None of the observable measures show the expected signs that were reported in Table IV. This suggests that there is a much weaker link between the firm's CCFS and its constraints-status. Only the intercept is always statistically significant with a value of around 0.14 indicating that the observed change in cash policy is not given in by the firm's liquidity position, debt position or profitability position but rather another exogenous unobserved variable. Moreover, the R^2 adjusted is considerably lower (around 6%) than in the ICFS-regression and the F-statistics usually suggest joint insignificance of the models. When ICFS is added as an extra dependent variable in columns

(5) and (6) we see again the significant negative coefficient, confirming the negative relation between ICFS and CCFS.

Overall, the ex-post regression indicates a tight and consistent link between the ICFS and the firm's constraints-status according to ex-post evaluation of the firm-varying sensitivities, whereas there seems to be no link between the CCFS and the firm's constraints-status. This finding in combination with the firm-level negative relation between the CCFS and ICFS seriously calls into question the recent development of estimating cash-cash flow sensitivities.

< Insert Table V around here >

IV. Conclusions

In this paper we predict and find empirical support for a negative relation between the firm's investment-cash flow sensitivity (ICFS) and the firm's cash-cash flow sensitivity (CCFS). As far as we know this is the first study to analyze both theoretically and empirically the link between these metrics, currently considered two separate and competing measures to assess the constraints-status of the firm.

This negative firm-level relation, which is embedded in the original theoretical model by Almeida et al. (2004) stems from the fact that both *investments* and the *cash-account* can be considered two rival uses of funds competing for the firm's limited available cash flows. Consequently, the firm's optimal amount of cash that will be transferred into the next period is inversely related to the optimal amount of investment that will be spent, both amounts depending upon the status of the current existing investment opportunities. As a result, a firm operating under a high ICFS over the observed sample period, will necessarily operate under a low CCFS and vice versa, holding constant all other uses of funds, leading to a negative firm-level relation between the two metrics.

We test the assertion empirically using a longitudinal dataset of 1,233 U.S.-based listed firms over a 5-year sample period and find substantial empirical support for the predicted relation. Additionally, we analyze the performance of the ICFS and CCFS-metric in terms of capturing financing constraints by regressing the ICFS and CCFS on a number of observables identified to have a clear relation with the firm's constraints-status (Whited and Wu, 2006; Hennessy and Whited, 2007). This ex-post approach is similar to the evaluative framework suggested in D'Espallier et al. (2008) and applied in Hovakimian and Hovakimian (2009). The results show a persistent relation between the firm's ICFS and its constraints-status with the R^2 adjusted suggesting that a significant proportion of variation in ICFS is driven by the existence of financing frictions. Conversely, for the CCFS we find no relation with any of the observable measures suggesting a much smaller link between the CCFS and the firm's constraints-status.

We believe that there are a number of interesting implications to this research. First, we hope to show that the firm's *investment* policy is closely linked with its *cash* policy, suggesting the need to analyze the firm's financial policies in combination with its real corporate policies rather than analyzing corporate decisions in isolation. In this respect our research fits into the literature trying to link different policies and investigate their combined impact on performance (Deshmukh and Vogt, 2005; Fisman and Love, 2003; Petersen and Rajan, 1994)

Secondly, our research calls into question the recent shift in attention towards estimating cash-cash flow sensitivities in order to circumvent some of the methodological problems related to estimating investment-cash flow sensitivities (such as potential endogeneity of the cash flow variable or difficulty in controlling for investment opportunities in the underlying investment equation). It seems that the ICFS-metric performs better in terms of capturing financing constraints, even when the caveats of potential endogeneity and difficulty in controlling for investment opportunities are kept in mind. The negative relation between the two metrics alongside the better performance of the ICFS-measure suggests that the CCFS-metric should be critically reviewed before it can be considered an adequate proxy to assess the degree in capital market imperfections. This conclusion is fully in line with the conclusions of Roddick and Whited (forthcoming) who argue that the firm's cash policy is determined by income shocks and taxation issues, rather than by the cost of external funds. Our paper reaches a similar conclusion and provides new empirical evidence to this assertion.

Finally, our research shows that the ex-post evaluative framework developed in D'Espallier et al. (2008) and Hovakimian and Hovakimian (2009) based upon firm-specific estimation is a considerable improvement over the traditional empirical framework in which sample-level estimates are compared against ex-ante classified groups. This paper is an attempt to draw upon this relatively new approach in order to shed new light on the established but still controversial ICFS-literature and the fairly novel CCFS-literature.

Evidently, this research comes with a number of limitations that should be kept in mind. First, the empirical results are based upon a specific sample (1,233 U.S.-based listed manufacturing firms) and a specific time-frame (five year time period from 2000 until 2004). This relatively short time-frame was chosen in order to retain a large number of observations, while reducing the computational complexity involved in running the GME-estimator. Obviously our research might be subject to the specificities of the observed sample period and it would be interesting to see whether the results would hold under more general conditions.

Secondly, this research is based upon a number of specific specifications for both the ICFS and CCFS-metric. The firm-level ICFS was estimated using a static augmented Q model of investment because this is clearly the specification most commonly applied in the literature. However, a number of recent studies experiment with different investment specifications such as dynamic neoclassical investment models (Bond et al., 2003; Guariglia, 2008), sales accelerator models (Kadapakkam et al., 1998; Hoshi et al., 1991) or specifications that take up different controls for the investment opportunities bias (Gilchrist and Himmelberg, 1995; Guariglia and Carpenter, 2008). It would be interesting to see whether the results hold for these alternative specifications that have been suggested in the previous literature.

Finally, the ex-post evaluative framework is based upon a wide set of observables that have been shown to have a close link with the firm's constraints-status. These observables are related to the firm's *liquidity* position, *debt* position and *profitability* position and have a long-standing tradition in the literature on financing constraints. However, there might be other observable measures of financing constraints that have not been used in this study or have been overlooked in the previous literature. Future research could be aimed at identifying other firm-observables related to the constraints-status of the firm and investigating the firm-level link with the ICFS and the CCFS.

Appendix A. The GME-estimator

The GME-estimator is a Quasi-Bayesian estimation technique based upon the principles of Information Theory. The estimator is developed and thoroughly discussed in the book by Golan et al. (1996). Applications of the GME-estimator to various fields in economics can be found in Judge and Golan (1992); Léon et al. (1999); Fraser (2000), Peeters (2004), among others. In this appendix we discuss the GME model formulation for the cash flow-augmented *investment* model given in equation (19) were Q is omitted for expository reasons. The GME formulation for the cash flow-augmented *cash* model is very similar and available from the authors upon request.

Following Golan et al. (1996) the GME formulation of the classical linear regression model can be written as:

$$\max_{p} \; H(\boldsymbol{p}) = -\sum_{k=1}^{K} p_k ln p_k \qquad \text{(A1)}$$

Subject to:

$$\boldsymbol{y} = X\boldsymbol{\beta} + \boldsymbol{e} = X\boldsymbol{Z}\boldsymbol{p} + \boldsymbol{V}\boldsymbol{w} \qquad \text{(A2)}$$

$$\sum_{k=1}^{K} p_{k,m} = 1 \qquad \forall m = 1, \dots M \qquad \text{(A3)}$$

$$\sum_{t=1}^{T} w_{t,j} = 1 \qquad \forall j = 1, \dots J \qquad \text{(A4)}$$

were $\boldsymbol{p}$ is a $(K \times M)$ matrix of unknown probabilities that need to be estimated; $\boldsymbol{Z}$ is a $(K \times KM)$ matrix of discrete support values for $\boldsymbol{\beta}$ with M the number of support points. Similarly, $\boldsymbol{V}$ is a $(T \times TJ)$ matrix of know support values for the error term $\boldsymbol{e}$ with J the number of support points and $\boldsymbol{w}$ the vector of unknown probabilities to be estimated. Equation (A1) represents the joint entropy of the parameters and the error term that need to be maximized with respect to $\boldsymbol{p}$. Equation (A2) represents the data-consistency constraint which is the parametrical version of the regression model that needs to be estimated. In this equation, each parameter is written as a linear combination of discrete support values and unknown parameters. Equations (A3) and (A4) represent additivity-constraints or normalization constraints that ensure that for each parameter the estimated probabilities add up to one. According to Golan et al. (1996) working through this maximization problem yields parameter estimates that are *least-informative* or expressing *maximum uncertainty* (i.e. closest to the discrete support values), while still consistent with the underlying model and the data.

Applying this model formulation to the cash flow-augmented investment model yields:

$$\max_{\boldsymbol{p}_\beta, \boldsymbol{p}_{\nu_{i,t}}, \boldsymbol{p}_{u_{i,t}}} H(\boldsymbol{p}) = -\boldsymbol{p}'_\beta ln\boldsymbol{p}_\beta - \sum_{i=1}^{n}\sum_{t=1}^{T} \boldsymbol{p}'_{\nu_{i,t}} ln\boldsymbol{p}_{\nu_{i,t}} - \sum_{i=1}^{n}\sum_{t=1}^{T} \boldsymbol{p}'_{u_{i,t}} ln\boldsymbol{p}_{u_{i,t}} \quad \text{(A5)}$$

Subject to:

$$(I/K)_{i,t} = \left(\boldsymbol{p}'_\beta \boldsymbol{z}_\beta + \boldsymbol{p}'_{\nu_{i,t}} \boldsymbol{z}_{\nu_{i,t}}\right)(CF/K)_{i,t} + \boldsymbol{p}'_{u_{i,t}} \boldsymbol{z}_{u_{i,t}} \qquad \forall i, t \qquad \text{(A6)}$$

$$\sum_{i=1}^{n}\sum_{t=1}^{T} \boldsymbol{p}'_{\nu_{i,t}} \boldsymbol{z}_{\nu_{i,t}} = 0 \qquad \text{(A7)}$$

$$\sum_{i=1}^{n} \boldsymbol{p}'_{u_{i,t}} \boldsymbol{z}_{u_{i,t}} = 0 \quad \forall t \qquad \text{(A8)}$$

$$\sum_{m=1}^{M} \boldsymbol{p}_{\beta,m} = 1;\ \sum_{g=1}^{G} \boldsymbol{p}_{\nu_{i,t},g} = 1;\ \sum_{h=1}^{H} \boldsymbol{p}_{u_{i,t},h} = 1 \qquad \forall i, t \qquad \text{(A9)}$$

In this constrained maximization problem (A5) is again the joint entropy of the parameters and the error term that needs to be maximized in order to obtain 'least-informative' parameter estimates closest to the support values. (A6) represents the data-consistency constraint which is the parametrical version of cash flow –augmented investment model where the unknown parameters are written as linear combinations of the unknown probabilities and discrete support values. Equation (A7) is a mean preservation constraint that ensures a consistent mean cash flow coefficient so that ‘shrinkage’ is avoided (Golan et al., 1996, pg. 163). Equation (A8) imposes a mean zero error in each year so that covariates and errors are determined exogenously. Equation (A9) represents the additivity-constraints that ensure that for each parameter to be estimated, the estimated probabilities add up to one.

The posterior parameter estimates can be recovered by recombining the optimal probabilities and the discrete support values in a linear way as follows:

$$\widehat{\boldsymbol{\beta}} = \widehat{\boldsymbol{p}}'_{\beta}\boldsymbol{z}_{\beta} \tag{A10}$$

$$\widehat{\boldsymbol{v}}_{i,t} = \widehat{\boldsymbol{p}}'_{v_{i,t}}\boldsymbol{z}_{v_{i,t}} \tag{A11}$$

$$\widehat{\boldsymbol{u}}_{i,t} = \widehat{\boldsymbol{p}}'_{u_{i,t}}\boldsymbol{z}_{u_{i,t}} \tag{A12}$$

In line with the Bayesian research paradigm, the GME estimator combines both prior information and data in order to form a posterior parameter estimate. Following prior information sets were used:

$$\boldsymbol{z}_{\beta} = [0,1]' \tag{A13}$$

$$\boldsymbol{z}_{v_{i,t}} = [-10,10]' \tag{A14}$$

$$\boldsymbol{z}_{u_{i,t}} = \left[-3\hat{\sigma}_{I/K_{i,t}}, 3\hat{\sigma}_{I/K_{i,t}}\right] \tag{A15}$$

Equation (A13) expresses that the supports for the mean cash flow coefficient were chosen to be distributed symmetrically around 0.50. Equation (A14) expresses a wide support value for the shrinkage-parameter $v_{i,t}$ and (A15) expresses that the priors for the error term are bounded by three times the empirical standard deviation of the dependent variable, consistent with the 'three-sigma' rule suggested in Pukelsheim (1994).

For the Bayesian researcher, combining prior information with data is a natural way to enhance parameter estimates. However, for researchers not adhering to the Bayesian paradigm, an objection often raised is the sensitivity of the results to using different information sets. While it is true that the prior information plays a role in the estimation process, its effect should not be overstated. First, when samples are sufficiently large, the information contained in the data often overshadows the information content provided by the non-sample information (Lancaster, 2004). Secondly, with the prior information sets wide enough and containing the true value of the parameter, the researcher imposes a minimal restriction and maximizes the influence of the data on posterior estimates (Koop, 2003). Therefore, we do not expect the support values to have a large impact on the GME-estimates.

However, in order to investigate the sensitivity of the estimates to the use of alternative prior information sets, we have conducted a sensitivity-analysis using the dual cross-entropy formulation in Golan et al. (1996). This procedure calculates the parameter estimates for 100 different prior values drawn randomly out of a distribution of choice. Specifically, 100 spike priors for $\boldsymbol{\beta}$ were drawn from a uniform distribution U(-1,1), a uniform distribution (-10,10) and a normal distribution N(0.5,0.3). This exercise reveals that the results are extremely insensitive to the use of different prior sets, which was to be expected given the large number of data points and the wide intervals that were used. Results from this exercise are available upon request.

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List of Tables

Table I. Summary statistics

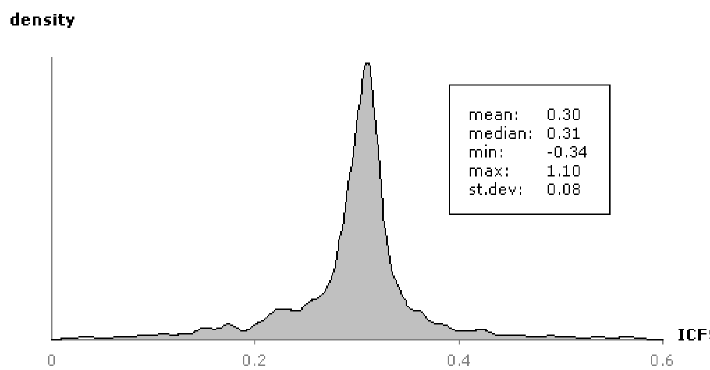
This table summarizes the number of observations, mean, standard deviation, minimum and maximum for a selection of financial variables from the sample of 6,165 firm-year observations. (I/K) is defined as investments in PP&E divided by beginning-of-year capital stock. (CF/K) is defined as net income before extraordinary items plus depreciation and amortization divided by beginning-of-year capital stock. Q is the beginning-of-year market value of common equity divided by beginning-of-year book value of common equity. Size is total assets in billion U.S.-dollar. Payout ratio is the sum of total dividends and stock repurchases divided by net income. Tangibility is PP&E divided by net fixed assets. Debt ratio is total debt divided by total assets. Cash/K is cash and equivalents divided by capital stock. Slack/K is (cash plus short term investments + 0.5 inventories+ 0.7 accounts receivables- short term loans) divided by capital stock. Sales is total net sales in billion U.S.-dollar. Sales growth is percentage growth in total net sales. Coverage is the interest coverage defined as EBIT divided by interest expenses and preferred dividends. Current ratio is current assets divided by current liabilities. ROE is return on equity defined as net income divided by beginning-of-year total common equity.

Variable	# obs	mean	median	st. dev	min	max
(I/K)	6,165	0.14	0.10	0.15	0.00	2.00
(CF/K)	6,165	0.37	0.21	0.57	0.00	5.00
Q	6,165	2.51	1.94	1.95	0.02	10
Size	6,165	1.66	0.48	3.25	1.61	42.26
Payout ratio	6,090	0.02	0.00	0.07	0.00	0.97
Tangibility	6,164	0.59	0.56	0.21	0.02	1.00
Cash/K	6,085	0.38	0.11	0.71	0.00	3.83
Slack/K	6,024	0.96	0.51	1.17	-1.69	4.50
Debt ratio	6,150	0.20	0.19	0.17	0.00	0.82
Sales	6,165	1.81	0.51	3.99	0.01	65.05
Sales growth	6,165	0.12	0.09	0.09	-0.81	1.00
Coverage	5,357	25.32	4.62	61.93	-7.00	300.00
Current ratio	6,006	2.69	2.03	2.63	0.22	47.56
ROE	6,158	0.11	0.10	0.09	-.15	0.40

Table II. Firm-varying sensitivities

This table reports a number of statistics for the for the 1,233 firm-varying ICFS-estimates and CCFS-estimates from the GME-estimation process in Panel A and Panel B, respectively. P(x) represents the x[th] percentile. The figures represent the kernel-density functions of the distribution of firm-varying ICFS and CCFS.

Panel A. ICFS-estimates	$\beta_{i,\ ICFS}$
mean	0.30
st.dev.	0.08
minimum	-0.34
maximum	1.10
P(0.01)	0.06
P(0.05)	0.17
P(0.10)	0.22
P(0.30)	0.29
median	0.31
P(0.60)	0.32
P(0.70)	0.32
P(0.90)	0.35
P(0.95)	0.40
P(0.99)	0.56
Proportion < 0	0.5%
Proportion in [0, 0.50[	97.8%
Mean lower 30% tail	0.23
Mean middle 40% area	0.30
Mean upper 30% tail	0.37



Panel B. CCFS-estimates	$\beta_{i,\ CCFS}$
mean	0.11
st.dev.	0.16
minimum	-0.57
maximum	1.64
P(0.01)	-0.40
P(0.05)	-0.16
P(0.10)	0.00
P(0.30)	0.09
median	0.11
P(0.60)	0.11
P(0.70)	0.12
P(0.90)	0.29
P(0.95)	0.32
P(0.99)	0.66
Proportion in [0, 0.50[	97.8%
Proportion in [0.50, 1]	1.94%
Mean lower 30% tail	-0.006
Mean middle 40% area	0.10
Mean upper 30% tail	0.22

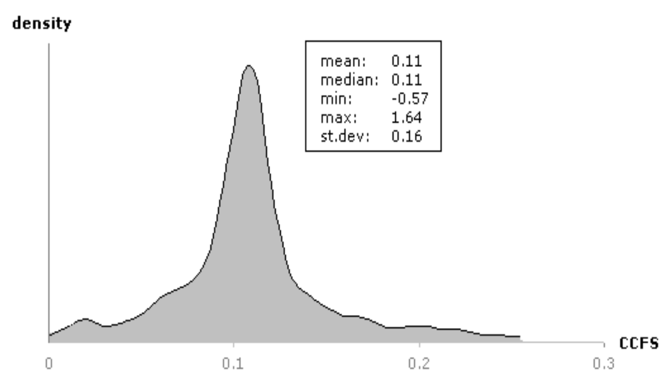


Table III. Negative relation between ICFS and CCFS

Panel A reports a number of summary statistics for the CCFS in a number of discrete classes with different ICFS-values. The different classes correspond to the 4 quartiles in the ICFS-distribution. Panel B analyzes the correlation between ICFS and CCFS directly by reporting the covariance and Pearson's correlation between the two metrics.

Panel A. CCFS in discrete ICFS-classes

	Very low ICFS ICFS< $P_{25\%}$ ICFS < 0.28	Low ICFS $P_{25\%}$<ICFS<$P_{50\%}$ 0.28<ICFS<0.30	High ICFS $P_{50\%}$<ICFS<$P_{75\%}$ 0.30<ICFS<0.32	Very high ICFS ICFS>$P_{75\%}$ ICFS>0.32
Mean	0.127	0.116	0.109	0.0711
Low	-1.52	-0.78	-0.33	-0.97
High	1.33	1.64	0.69	0.75
St.dev.	0.23	0.01	0.08	0.01

Panel B. correlation between ICFS and CCFS

Covariance	-0.0011
Pearson's correlation	-0.083***
Spearman's rho	-0.115***
Kendall's tau	-0.085***

Note: *** denotes statistical significance at the 1% significance level

Table IV. Observables related to financing constraints

This table summarizes the financial variables that have been used in the ex-post regression analysis (column 1) and their definition (column 2). In the third column we indicate the expected relation with the sensitivity in the ex-post regression analysis. All variables are defined as in Table I.

Financial observables	variables definition	Expected coefficient sign *If the sensitivity is a positive indicator of financing constraints we expect following sign in the ex-post regression analysis:*
Dividend payout	Payout ratio	-
Leverage	Debt ratio	+
Growth	Sales growth	-
Size	Natural logarithm of total assets	-
	Natural logarithm of sales	-
Cash	Cash ratio	-
	CF/K	-
Profitability	ROE	-
	Coverage	-

Table V. Ex-post regression analysis

This table summarizes the results from regressing the firm-level sensitivities on a number of observable measures related to the constraints-status of the firm using OLS. Panel A presents the regression output for the ICFS-metric and Panel B presents the regression output for the CCFS-metric. Robust standard errors are reported in parentheses. *,** and *** denote statistical significance at the 10%, 5% and 1% significance level, respectively. The different columns correspond to alternative definitions that were taken up subsequently for the same financial observable (*size* is measured both in *sales* as well as *lnTA*; *profitability* is measured both in terms of *ROE* and *interest coverage*; *cash* is measured in terms of the *cash rate* as well as *cash flow*).

Panel A. Regressing the ICFS on the observable measures

Dep. var. $ICFS_i$	(1)	(2)	(3)	(4)	(5)	(6)
Payout ratio	-0.07	-0.02	-0.06	-0.04	-0.07	-0.05
	(0.046)*	(0.022)*	(0.051)***	(0.035)***	(0.045)***	(0.014)***
Debt ratio	0.10	0.12	0.11	0.10	0.10	0.11
	(0.025)***	(0.024)***	(0.025)***	(0.023)***	(0.025)***	(0.022)***
Sales growth	-0.03	-0.03	-0.04	-0.01	-0.03	-0.01
	(0.041)	(0.038)	(0.041)	(0.039)	(0.041)	(0.037)
Interest coverage	-0.07		-0.07	-0.06	-0.07	
	(0.028)**		(0.028)**	(0.029)**	(0.029)**	
ROE		-0.01				-0.01
		(0.001)***				(0.002)**
LnTA	-0.004	-0.004		-0.003	-0.005	
	(0.002)***	(0.001)***		(0.001)**	(0.002)***	
lnSales			-0.01			-0.01
			(0.002)***			(0.001)***
Cash/K	-0.02	-0.02	-0.02		-0.02	
	(0.003)***	(0.003)***	(0.003)***		(0.004)***	
CF/K				-0.10		-0.09
				(0.009)***		(0.008)***
CCFS					-0.02	-0.01
					(0.018)*	(0.015)*
Constant	0.33	0.36	0.33	0.36	0.36	0.33
	(0.009)***	(0.012)***	(0.011)***	(0.012)***	(0.013)***	(0.010)***
N	1219	1211	1109	1117	1109	1219
F-stat	34.21***	19.07***	14.42***	23.34***	13.21***	31.59***
R^2 adj.	0.39	0.36	0.33	0.37	0.32	0.39
RMSE	0.08	0.09	0.09	0.09	0.09	0.08

Table V. continued

Dep. var. $CCFS_i$	(1)	(2)	(3)	(4)	(5)	(6)
Payout ratio	-0.03	-0.02	-0.03	0.00	-0.03	-0.05
	(0.074)	(0.021)	(0.074)	(0.075)	(0.073)	(0.020)*
Debt ratio	-0.04	-0.03	-0.04	-0.05	-0.04	-0.04
	(0.028)	(0.028)	(0.027)	(0.029)*	(0.029)	(0.029)
Sales growth	0.07	0.13	0.06	0.07	0.07	0.14
	(0.058)	(0.062)	(0.058)	(0.058)	(0.058)	(0.062)**
Interest coverage	-0.01		-0.01	-0.01	-0.02	
	(0.103)		(0.103)*	(0.101)*	(0.104)*	
ROE		0.00				0.00
		(0.003)				(0.000)
LnTA	0.00	0.00		0.00	0.00	
	(0.002)	(0.003)		(0.002)	(0.002)	
lnSales			0.00			0.00
			(0.002)			(0.002)
Cash/K	0.00	0.01	0.00		0.00	
	(0.006)	(0.006)	(0.007)		(0.006)	
CF/K				-0.02		-0.01
				(0.017)		(0.017)
ICFS					-0.02	-0.04
					(0.046)*	(0.051)**
Constant	0.14	0.14	0.14	0.15	0.15	0.17
	(0.019)***	(0.019)***	(0.015)***	(0.019)***	(0.024)***	(0.019)***
N	1109	1211	1109	1117	1109	1219
F-stat	1.66	2.37	4.18**	4.12***	4.38***	5.74***
R^2 adj.	0.06	0.05	0.06	0.06	0.06	0.05
RMSE	0.15	0.15	0.14	0.14	0.14	0.15