Cash Flow Volatility, Financial Slack and Investment Decisions

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Laurence Booth (University of Toronto)
Sean Cleary (St. Mary's University)*

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Corresponding Author:

Sean Cleary
Sobey School of Business
Saint Mary's University
Halifax, Nova Scotia B3H 3C3
Tel: (902) 420-5726
E-Mail: sean.cleary@smu.ca

Abstract

We examine firm investment decisions when faced with market imperfections that drive a wedge between the cost of internal and external financing. We consider the role played by both cash flow volatility and financial slack, and how they interact in the presence of financial constraints to affect investment-cash flow sensitivities. We demonstrate that the investment outlays of firms with high cash flow volatility will be *less* sensitive to a given period's internal cash flow. The reason for this is simply that such firms will build up financial slack in the full knowledge that such cash flow volatility would otherwise reduce investment due to the wedge between internal and external capital costs. That is, firms facing financial constraints will anticipate their effect by building up more financial slack and having stronger balance sheets. Consequently, firms facing financial constraints will strengthen their balance sheets and exhibit less correlation between future cash flows and investments than will firms facing lower constraints.

Our empirical evidence provides strong support for these theoretical predictions. In particular, our results confirm that firms with high cash flow volatility maintain the highest levels of financial slack and that their investment outlays are the least sensitive to the firm's internally generated cash flows. The model and empirical results in this paper go a long way to reconciling the existing empirical literature where there is significant disagreement on the proxies used to demonstrate whether a firm operates under "financial constraints."

1. Introduction

There is a large empirical and theoretical literature that examines how firms make investment decisions in the face of market imperfections such as agency costs and informational asymmetry problems. In general the models take as their base case the standard Modigliani and Miller (1958) model that financing does not matter and then relax their perfect market assumptions. The general effect of these relaxations, for example, of symmetric information between managers and shareholders (Myers and Majluf 1984) or agency problems (Donaldson 1964) is to drive a wedge between the costs of internal and external capital. This explicitly creates a role for the amount of internal cash flow in the determination of the firm's optimal amount of investment. However, despite extensive empirical research stretching back over at least the last twenty years there is no consensus as to the impact of market imperfections on investment outlays. In fact, the existence of a large number of contradictory empirical results has led to an ongoing debate as to which factors represent the best proxies for "financial constraints" and whether any or all affect corporate investment decisions.

We extend this literature by developing a theoretical model that accounts for firm investment decisions when faced with financial constraints. Our model highlights the importance of a critical variable that has largely been ignored in both prior theoretical and empirical work dealing with investment-cash flow sensitivity – namely the underlying volatility of the firm's internal cash flows.[1] In addition, by focusing on the role played by financial slack, we provide an important and distinct perspective on the investment decision making process. We argue that the investment outlays of firms with high cash flow volatility will be less sensitive to a given period's internal cash flows. In addition, these firms will tend to hold significant amounts of financial slack in order to better fund these future investments without resorting to external capital markets.

We test this model using a large balanced sample of U.S. firms over the period 1981 to 1998 and the empirical work provides strong support for our theoretical model In particular, our results confirm that cash flow volatility has a significant impact on the amount of financial slack a firm maintains, and on its investment-cash flow sensitivity. We find that firms with high cash flow volatility maintain higher levels of financial slack than their counterparts with low cash flow volatility, and that the investment outlays of these firms are less sensitive to the firm's internally

[1] One exception is Cleary (2006) who uses a seven-country international sample and finds that "firms possessing high volatility of cash flow tend to display lower investment-cash flow sensitivities."

generated cash flows. These results go some way to reconciling the results in the existing literature in that our results show that while financial constraints do matter, building up financial slack helps to ameliorate the effect.

The rest of the paper is organized as follows: Section 2 presents motivation for our study; Section 3 presents our theoretical model; Section 4 describes the data and provides summary statistics; Section 5 provides the results of our investment regressions; and Section 6 concludes.

2. Motivation

Financial constraints affect corporate investment decisions when firms face imperfect or incomplete capital markets so that the cost of external capital exceeds that of internal capital; that is there is a wedge between the two.[2] The existence of this wedge causes capital rationing in that firms can not accept all projects that have positive new present values based on their internal cost of capital. It follows that a positive cash flow shock to the firm, by increasing the supply of internal capital, will increase investment. It is not surprising therefore that there is significant empirical as well as anecdotal support for the observation that investment outlays are sensitive to the availability of internal cash flow. These empirical observations are consistent with the existence of a financing hierarchy, where firms finance investments primarily through internal funds, and then bank and public market debt, while issuing equity as a last resort. Myers and Majluf (1984) justify the financing hierarchy based on informational assymetries, whereby managers have superior inside information and believe the stock price to be undervalued. In contrast, Donaldson (1963) justifies the financing hierarchy based on a division of management control from ownership and the differing goals of managers concerned with the survival of the firm. In this case, investment is restricted to internal cash flow due to the risk aversion of managers and their reluctance to issue public market debt or equity.

Regardless of the agency versus informational asymmetry justification, the existence of a financing hierarchy implies the existence of a financial constraint in that whether self imposed or imposed by financial markets there is a perceived wedge between the costs of internal and external capital. Although the theoretical models are widely accepted the critical empirical question is the correct proxy for this financing wedge. For example, previous studies have argued that the investment outlays of small firms and/or firms with low payout ratios would be the most sensitive to internal

[2] See Hubbard (1998) for a summary of the investment literature.

cash flow. Plausibly small firms face greater information assymetries and agency costs, as well as transactions costs in accessing markets, while low dividend payouts indicate relative low levels of residual income. Early empirical work confirmed these conjectures, for example, Gilchrest and Himmelberg (1995) found that small firms displayed higher investment-cash flow sensitivity than larger firms, while Fazzari, Hubbard and Petersen (1988) and several others found that low payout firms were more cash flow sensitive than high payout firms.

However, more recent empirical evidence has produced contradictory findings. For example, Cleary (2006) and Kadapakkam, Kumar and Riddick (1998) find that larger firms are more cash flow sensitive than smaller firms, while Cleary (2006) and Gilchrest and Himmelberg (1995) find that firms with higher payout ratios display higher investment-cash flow sensitivity than low payout firms. Perhaps the most controversial results are those of Kaplan and Zingales (1997) and Cleary (1999) who both find that the investment decisions of firms with stronger financial positions are much more sensitive to the availability of internal funds than those that are less creditworthy. In this case, "stronger financial position" means higher profitability and stronger balance sheets in the sense of less debt.

Several plausible explanations have been advanced to explain these contradictory results. First as previously mentioned it is difficult to find accurate empirical proxies for the existence of financial constraints as discussed by Cleary, Povel and Raith (2006) and others. Second, estimating investment-cash flow sensitivity is problematic due to measurement errors associated with the proxy variables and the controls for growth opportunities. While these reasons are valid, they do little to shed light on what does affect investment in the face of financial constraints.

We provide insight into this issue in two important ways. First, we focus on the role played by cash flow volatility in the investment decision both directly and indirectly. We show that in addition to the direct detrimental influence that cash flow volatility has on investment, it also affects a firm's decision to build up financial slack, which in turn affects a firm's investment-cash flow sensitivity. While neither of these ideas is new in itself, we are the first to formally incorporate them into a model that deals with firm investment outlays in the presence of financial constraints. For example, Minton and Schrand (1999) document the existence of the direct relationship between cash flow volatility and investment outlays, finding that firms with high cash flow volatility invest less and are inclined to decline potentially attractive investments. They argue this is due to the high costs of accessing external funds for firms with high cash flow volatility, but they say little regarding the impact of this volatility on the firm's investment-cash flow sensitivity or its financing policies. On the other hand, Opler et al (1999) argue that firms with volatile cash flows that possess high future growth opportunities will hold higher cash balances, which are positively related to, but not exact proxies for, financial slack. However, they say little about the influence this has on firm investment outlays. Finally, Cleary (2006) finds empirical evidence that suggests cash flow volatility affects investment-cash flow sensitivities, and suggests this may be related to several of the seemingly contradictory empirical findings in the literature. Our theoretical model and empirical results tie all of these "pieces of the puzzle" into a comprehensive analysis of the role played by cash flow volatility in the investment decision.

In addition to considering the role played by cash flow volatility, our theoretical model moves this literature forward by appealing to the important, but somewhat neglected role played by financial slack, even though it is implicit in both the agency and asymmetric information explanations justifying a financing hierarchy. The specific genesis of our focus is a suggestion by Hubbard (1998) who states "it is important to consider investment and financial policy jointly; firms may, for example, accumulate liquidity as a buffer against future constraints." What this means is that firms recognize the existence of financial constraints and that they take steps to ameliorate their impact. How this affects the proxies used for the existence of financial constraints and what it means for the empirical design of tests of investment-cash flow sensitivity has not so far been developed explicitly; although Almeida et al (2004) have recently initiated this process by showing that firms facing the highest financial constraints will build up higher cash balances in order to fund future investment opportunities.

In short, our paper makes an important contribution to our understanding of firm investment and financing behaviour by considering the role played by both cash flow volatility and financial slack, and how they interact in the presence of financial constraints to affect investment-cash flow sensitivities.

3. A Model of Firm Decision Making

To motivate the impact of financial constraints consider a simple model of a firm making investment (I_t) decisions over multiple periods. At time 0 the firm makes an investment and also raises financial capital, while at time 1 there is further investment, but the firm also generates cash flow (C_t) from the first period's investment and funds any cash flow shortfall. Any shortfall between the firm's financial resources and the funds needed for investment is financed either at time period 0 or 1 or both. For valuation purposes we can use a stripped down version of Miller and Modigliani's (1961) investment opportunities formula

$$V_0 = \frac{C_1}{K} + \frac{I_1}{(1+K)}(NPV_1) \tag{1}$$

In this equation, firm value (V_0) is determined as the present value of the earnings from the initial investment, assumed for convenience to be a perpetuity, plus the net present value of the investment at time 1.

The M&M model assumes perfect capital markets. However, in raising funds the firm is usually faced with a "wedge" between the costs of internal versus external capital, which is caused, for example, by transactions costs, agency costs, managerial risk aversion or information asymmetries. Regardless of the source of the wedge, we assume that the value loss to raising external capital is convex in the amount raised. This assumption is consistent with the studies referenced by Hubbard (1998) as well as the normal development of the marginal cost of capital developed in an introductory finance text, such as Brigham et al (1999, page 41). An increasing marginal cost of capital schedule essentially means that the external financing wedge increases as the firm moves to raise capital from short-term bank debt to long-term bonds to new equity.

The value of the firm can then be solved as a dynamic programming problem by first determining the optimal amount of investment at time t and the resulting NPV impounded in firm value at time t-1 and then solving for the optimal investment at time t-1 etc. As of time t the problem is as follows:

$$\frac{MAX}{I_t} = V(I_t) - I_t - \gamma_t(I_t - (F_{t-1} - I_{t-1})(1+r) - C_t) \tag{2}$$

The *V(.)* function is simply the value function for investment at time t. It reflects the present value of the expected future cash flows discounted at the firm's internal cost of capital. The gamma function represents the value loss from raising external capital with $(F_{t-1}-I_{t-1})(1+r)$ representing the current value of the financial slack available from the funds left over from the prior period's investment where these funds earn the return on marketable securities *r*. The available funds (A_t)

are simply the current value of the financial slack plus the cash flow (C_t) for the period. The difference between available funds and investment is financed with external capital that incurs a value loss due to the external financing wedge.

The optimal investment decision occurs where the following condition holds:

$$V^{'}(.) - 1 - \gamma_t^{'}(.) = 0 \tag{3}$$

If there is no wedge attached to external capital *(γ' ()=0),* then capital markets are perfect. In this case the standard NPV criterion applies, where all projects are accepted until the last dollar of investment, as determined by the firm's "internal" cost of capital, also increases market value by a dollar. This is Modigliani and Miller's (1958) third proposition, where financing per se does not affect the investment decision. It implicitly assumes the absence of a wedge between the cost of internal and external capital.

In the face of financial constraints, where external capital is more expensive, investment is restricted as the incremental value (*V'(.)*) has to equal one plus the costs of the financing wedge (*1+γ' (.)*). As the impact of the financial constraints increases, the firm's investment will decrease. However, the importance of this constraint depends on the available funds and the financial slack from the prior period. The optimal NPV at time t can be found by inserting (3) into (2) or

$$NPV_t^* = NPV(X_t, A_t) \tag{4}$$

Where X_t represents the set of exogenous variables affecting the value function such as the internal cost of capital, forecast cash flows etc and A_t is the available funds at time t. Unlike the standard perfect markets model, the NPV function explicitly accounts for both the financial slack and the cash flow available to the firm, since together these determine available funds and the impact of the wedge between the costs of internal versus external capital.

For the prior time period, the NPV is uncertain, since it depends on the uncertain cash flow at time *t*, since this affects available funds.[3] The firm's prior decision is therefore

[3] The value function itself may change due, for example, to changes in expectations for the firm's future cash flows. However, we ignore such changes for two reasons. First, our focus is on the external financing wedge. Second, the

$$\frac{Max}{I_{t-1}} = V(I_{t-1}) - I_{t-1} - \gamma_{t-1}(I_{t-1} - A_t) + V_{t-1}(NPV_t^* + r(F_{t-1} - I_{t-1})) \qquad (5)$$

The first part ($V(I_{t-1})$-I_{t-1}- $\gamma(I_{t-1}$-$A_t)$) is identical to the investment decision at time t, the last term reflects the present value of the NPV at *t* as well as the income from investing the financial slack in marketable securities. Unlike the investment at time *t*, in the face of financial constraints the firm has to consider the value of available funds used today versus in the future. This is because with a fixed stock of available funds, current investment reduces the available funds for the future and thus the future effect of the financial constraint.

In standard investment models, the perfect capital markets assumption allows each period's investment decision to be decoupled from the firm's financial status and prior investment decisions. However, in the face of financial constraints, the amount of available funds or internal capital decreases the severity of the constraint and is thus a state variable that affects all future investment decisions. For example, it is clear from the formulation of equation (2) that an exogenous increase in available funds decreases the effect of the financial constraint and unambiguously increases investment and the optimal NPV; that is, available funds are valuable. However, only part of the available funds are determined by the firm, the cash flow at time *t* is uncertain and determined by the firm's operations. However, apart from the scaling by the investment return the impact of the cash flow at time *t* is identical to the impact of financial slack at time *t-1:* increases in cash flow reduce the impact of the financial constraint and reductions increase it.

As of time t-1, the uncertainty in cash flow at time t introduces uncertainty into the NPV function. For a given stock of available funds, increased cash flow volatility reduces the value of the future period's NPV. This is because the investment value function is monotonically increasing, but at a decreasing rate, in the available funds. This follows from the concavity of the value function and the fact that the firm undertakes the most profitable projects first. Consequently, all else constant, as cash flow increases the firm can undertake more investments, but the profitability of these projects declines until the effect of the financial constraint is removed; after which an incremental dollar of cash flow is simply worth a dollar, since it does not affect investment. As a result an

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empirical literature controls for value changes (growth opportunities) by using Tobin's q (market-to-book ratio) as a control.

increase in volatility around a given forecast cash flow increases the severity of the financial constraint and reduces the current value of the forecast NPV.

Consequently, the key insight from the NPV function in equation (5) is that increased cash flow volatility and reduced forecast levels of cash flow both increase the severity of future financial constraints and increase the value of financial slack. Take two extreme examples, the first is a utility and the second a pharmaceutical or high tech stock. The utility has very strong stable cash flows and relatively little investment as a "mature" company. Working back from equation (5) the utility managers can predict their future cash flow and investment very accurately since there is no reason for building up financial slack. Consequently, their financial structure can be aggressive with more use of debt and little financial slack in the form of marketable securities. More to the point, their forecast cash flow and investment can be correlated. In contrast, a pharmaceutical or high tech growth stock might forecast significant future investments and relatively low levels of highly volatile cash flows. In their case, financial slack has significant value so that faced with financial constraints they would have little debt and significant marketable securities. More to the point there would be little correlation between their cash flow and investment simply because they would have built up financial slack to pre-fund the shortfall between the two.

Working back sequentially from equation (5) we can see that the generalization of the M&M valuation formula will include the impact of financial slack and that in the initial period the firm will chose not just its level of investment but also its initial financing. For most firms the initial amount of financial slack has already been predetermined and can be treated as exogenous. However, for start ups we have

$$\frac{Max}{I_0, F_0} = V(I_0) - I_0 - \gamma_0(I_0 - F_0) + \sum_{t=1}^{T} V_t(NPV_t^* + r(F_t - I_t)) \qquad (6)$$

The investment decision is straightforward. The new optimality decision is simply building up the initial capital and financial slack (F_0), where increased financial slack causes immediate value loss as well as a subsequent opportunity cost, since the return from marketable securities is less than the investor's opportunity cost, but reduces the severity of subsequent financial constraints.

The optimal solution to (6) varies with firm characteristics and the effect of the financial constraint. For high tech stocks and the existence of IPO waves, it explains why such firms raise as much capital as possible and then burn through the capital to finance investment over multiple periods.[4] In their case, the IPO "window" allows them to raise capital that exceeds their current needs at relatively low cost while the effect of future financial constraints is severe. In contrast, traditional cash flow positive firms are plausibly subject to less variability in the IPO window and are less affected by financial constraints.

The main insights of the model are to indicate that there is value to financial slack when there is a wedge between internal and external capital. The firms that have the most value to adding financial slack are those with the most volatile future cash flows and those which face the largest wedge between internal and external capital. This model of pre-financing has two main empirical implications that are in contrast to the existing literature and which we test in the following sections:

> 1) Firms facing the greatest wedge between internal and external capital and highest cash flow volatility will maintain the highest levels of financial slack (i.e., lowest debt ratios and highest liquidity ratios) and appear to be in the best "financial health" based on traditional ratios.
>
> 2) The investment outlays of firms with significant financial slack will only be loosely correlated with their cash flow.

The reverse is obviously also true that firms with the least volatile cash flows will see little value to financial slack and will maximize the use of debt. As a result they will appear to have 'weaker" financial health and have investment more highly correlated with their cash flow.

Note that these hypotheses differ from those frequently advanced, where generally it is argued that firms that face the greatest financial constraints and have the greatest correlation between internal cash flow and investment. However, the critical point is that firms "choose" whether to maintain high or low levels of financial slack based on their knowledge of the wedge between internal and external capital, and the volatility of their future cash flows. The Appendix contains an illustrative example of the model and the implications for investment and financing decisions.

4. Sample Characteristics

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[4] At the IPO date raising equity capital as the primary security is normally subject to decreasing costs due to the large fixed cost component attached to raising equity capital.

We use annual data for U.S. firms from a wide variety of industries over the 1981 to 1998 period that was collected from the Research Insight (US Compustat) database. All available firm year observations were collected and deletions were made only if the value for either total assets or sales were zero, or if they were missing values for the market-to-book ratio (M/B), cash flow-to-net fixed assets (CF/K), or investment-to-net fixed assets (I/K). We use the resulting observations to construct a balanced panel dataset, which requires that a given firm had observations available for each of the years 1981 to 1998. This approach left us with 20,394 firm-year observations based on 18 annual observations for 1,133 firms. The use of a balanced sample was necessary in order to obtain estimates of cash flow volatility for each firm in our sample, which requires a reasonable number of observations for each firm.

Panel A of Table 1 presents median values over the 1981 to 1998 period for several financial variables for the entire sample and for several sub-samples.[5] The reported financial variables include a measure for firm size (total assets); the three variables used in our investment regressions (I/K, CF/K, and M/B); several variables related to firm debt, liquidity and profitability (debt ratio, current ratio, slack, net income margin, and dividends to EBIT); and our two measures of cash flow volatility (Vol(CF/K) and CV(CF/K)). I/K is measured as the ratio of firm investment outlays (i.e., capital expenditures) divided by the beginning of period value for net fixed assets (K), while CF/K is measured as firm cash flow (net income before extraordinary items plus depreciation) divided by K. M/B is the beginning of period value for the firm's market value of common equity, divided by the book value of common equity. Slack is constructed by dividing the current ratio by the debt ratio. It will be higher for firms possessing lower debt ratios and higher current ratios, which represent the two characteristics (debt levels and liquidity) that we wish to associate with financial slack. Our first measure of cash flow volatility is Vol(CF/K) which is the standard deviation (volatility) of a firm's cash flows over the 18-year period and is a standard measure of volatility. Our second measure, CV(CF/K), is the coefficient of variation of CF/K, which accounts for the size of the firm's cash flows as well as the volatility of those cash flows.

The top row in Panel A of Table 1 presents the median values for the total sample, while the remaining rows report results for various sub-groups that have been formed in order to test our hypotheses. The first three sub-groups are constructed based on firm size, as measured by total

[5] We report the medians because they are more informative than the means for several of the ratios, which are distorted by outliers.

assets in a given year, with TA1 being the smallest third of firms, TA2 being the next biggest third and TA3 being the largest third. This grouping is designed to distinguish between firms facing different levels of asymmetric information and agency costs that drive a wedge between the cost of internal and external funds, with the null hypothesis being that smaller firms face greater such problems, and therefore have a larger wedge between the cost of internal and external funds. Our theory predicts that such firms will maintain higher levels of financial slack as a result of this larger wedge. This prediction is borne out by the summary statistics, where we see that small firms have lower debt ratios, higher current ratios, and higher slack ratios than their medium-sized and large-sized counterparts, and the medium-sized firms compare similarly to the large firms. Table 2 provides evidence that these differences are all statistically significant. In particular, Panel A presents the results of non-parametric tests (Mann-Whitney tests) that compare the "location" of the sub-sample distributions, while Panel B presents the results of standard t-tests that test for equality of the means across the sub-samples.

The next four sub-groups in Panel A of Table 1 are quartiles that are constructed based on our first measure of cash flow volatility (Vol(CF/K)), while the next four sub-groups are quartiles that are constructed based on CV(CF/K). The statistics for these sub-groups provide strong support for our assertion that firms with higher cash flow volatility would maintain higher levels of financial slack. In particular, the debt ratios increase, while the current ratios and slack ratios decrease monotonically as we move from quartile 1 (low volatility) to quartile 4 (high volatility), based on both cash flow volatility measures. Table 2 shows that these differences are all statistically significant at the 1% level across the Vol(CF/K) quartiles, as are most of the differences across the CV(CF/K) quartiles.

Another pattern that is obvious in Table 1 is that smaller firms have more volatile cash flows than larger ones, as we would expect. Panel B of Table 1 provides summary statistics for debt ratios, current ratios and slack ratios for sub-groups within the size sub-groups that are formed based on the cash flow volatility quartiles that were formed for the entire sample. The first four rows of Panel B presents the same pattern provided in Panel A for the Vol(CF/K) quartiles: firms with more volatile cash flows maintain higher financial slack. This suggests that even after controlling for the effect of firm size, higher cash flow volatility leads a firm to choose higher financial slack. The pattern for the CV(CF/K) quartiles within the size sub-groups is evident, but is weaker than it was in the total sample.

If we look at the extremes in Panel B of this table (i.e., the big, low cash flow volatility firms versus the small, high cash flow volatility firms), we see the predicted marked difference in the debt, current, and slack ratios. The big, low volatility firms have the highest debt ratios, and the smallest current and slack ratios across all 12 sub-groups based on each of the volatility measures. Similarly, the small, high volatility firms have the lowest debt ratios, the largest current ratios and the highest slack ratios for the Vol(CF/K) quartiles. The small, high volatility firms have only the third lowest debt ratios, and the third highest current and slack ratios for the CV(CF/K) quartiles; although the values are very close to the top two, they are markedly different than those for the big, low volatility firms, as predicted.

5. Regression Results

The previous section confirms our predictions that firms facing a higher wedge between the cost of internal and external funds, and those with higher cash flow volatility will maintain higher levels of financial slack. This section examines our hypothesis that these firms will also display lower investment-cash flow sensitivities using the traditional regression specification used in numerous previous studies. In particular, the following regression equation model is estimated:

$$I/K_{it} = \beta_{M/B}(M/B)_{it} + \beta_{CF/K}(CF/K)_{it} + u_{it} \qquad (7)$$

This is the basic equation estimated by Kaplan and Zingales (1997) and Cleary (1999) among others, where the market-to-book ratio is used as a proxy for growth opportunities, and current period cash flow (CF), scaled by "K," used to measure the availability of internally generated funds. Similar to previous evidence, the reported regression results are estimated using fixed effects to control for firm and time specific influences.[6]

Regression estimates for the total sample presented in Panel A of Table 3 indicate that firm investment decisions are sensitive to investment opportunities as proxied by market-to-book, but are even more sensitive to cash flow. This is consistent with previous evidence and confirms the importance of internal fund availability for investment outlays.

[6] The reported fixed effects estimates are obtained by "demeaning" the observations with respect to the firm and year average for that variable.

The results for the size groups presented in the next three rows confirm our hypothesis regarding the investment behavior of firms facing greater informational asymmetries and agency costs. In particular, the smaller the firm, the lower the investment-cash flow sensitivity, as measured by the coefficients on the CF/K terms in the regression equation. These results contradict the results of Gilchrest and Himmelberg (1995); however, it is consistent with more recent international (including the U.S.) evidence provided by Kadapakkam, Kumar and Riddick (1998) and Cleary (2006) who find that the investment outlays of smaller firms are more sensitive to cash flow than they are for larger firms.

Panel B of Table 3 confirms that small firms (TA1) display significantly lower investment-cash flow sensitivity (at the 1% level) than both medium-sized firms (TA2) and large firms (TA3), and that TA2 firms are significantly less sensitive than TA3 firms (also at the 1% level). The significance of the coefficient estimate differences can be inferred from the presented t-statistics, which are estimated on cross-dummy variable coefficients. The cross-dummy variables are constructed by multiplying the independent variables (M/B and CF/K) by the respective sub-group dummy variable. Regressions are run with the sub-group dummy variable included, and with the cross-dummy variables. If the two sub-groups have the same coefficient on the respective independent variable (i.e., M/B or CF/K), the cross-dummy variable will be insignificant. Therefore, if the cross dummies are significant it indicates that the coefficient estimates differ significantly across the two sub-groups. For each regression, the dummy variable included equals 1 if the observation is from the first sub-group listed, and 0 if it is from the second sub-group.
The next eight rows in Panel A of Table 3 presents the regression results for the Vol(CF/K) and CV(CF/K) quartiles, which provides strong support for our assertion that firms with higher cash flow volatility will display lower investment-cash flow sensitivity. The CF/K coefficient declines monotonically from 0.654 and 0.541 for the respective low volatility quartiles to 0.150 and 0.139 for the respective high volatility quartiles. Panel B indicates that all of the differences between the group estimates are significant at the 1% level. These results are consistent with the recent international (and U.S.) evidence provided by Cleary (2006) over the 1987 to 1997 period.

Table 4 presents the results of regressions conducted on the volatility sub-groups within the size groups. While the evidence is still supportive of a decline in investment-cash flow sensitivity as cash flow volatility increases, it is much weaker within the size sub-groups than it is for the total sample. This can be attributed to the strong interrelationship between firm size and cash flow volatility that was identified in the previous section – i.e., smaller firms tend to have more volatile cash flows than large ones. However, we can view this another way by examining the "extreme" sub-groups: we would expect large firms with low cash flow sensitivity to display the highest investment-cash flow sensitivities, and we would expect that small firms with high cash flow volatility to display the lowest investment cash flow sensitivities. Examining Panel A of Table 4, we observe that small firms in Vol(CF/K) Quartile 4 do in fact display the lowest CF/K coefficient across all 12 Vol(CF/K) sub-groups (0.125), and that this is also true for small firms in CV(CF/K) Quartile 4, with a CF/K coefficient of 0.116. However, big firms in Vol(CF/K) Quartile 1 display only the second largest coefficient across the 12 Vol(CF/K) Quartile sub-groups at 0.730 versus 0.826 for small Quartile 1 firms. Similarly, big firms in CV(CF/K) Quartile 1 have only the third largest coefficient (0.537), lagging both large firms Quartile 4 (0.721) and medium-sized firms Quartile 1 (0.565). These two unexpected results are at least partially attributable to the small size of the sub-samples displaying the unexpectedly higher cash flow sensitivity.

6. Conclusions

We present a theoretical model that accounts for firm investment decisions when faced with market imperfections that drive a wedge between the cost of internal and external financing. The uniqueness of the model arises from our incorporation of the roles played by a firm's cash flow volatility and its subsequent choice of financial slack. We demonstrate that the investment outlays of firms with high cash flow volatility will be less sensitive to a given period's internal cash flows. In addition, these firms will be inclined to build up a significant amount of financial slack in order to be better able to fund future investments without having to raise capital from external capital markets. In short, our paper considers the role played by both cash flow volatility and financial slack, and how they interact in the presence of financial constraints to affect investment-cash flow sensitivities.

Empirical evidence based on an examination of a large balanced sample of U.S. firms over the 1981 to 1998 period provides strong support for our theoretical predictions. Our results confirm that cash flow volatility has a significant impact on the amount of financial slack a firm maintains, and on its investment-cash flow sensitivity. We find that firms with high cash flow volatility maintain the highest levels of financial slack and that their investment outlays are less sensitive to the firm's internally generated cash flows.

These observations help to reconcile some of the recent apparently contradictory findings in the empirical investment literature, which may be attributed at least in part to the important role cash flow volatility and financial slack play in investment decisions.

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APPENDIX

An Illustrative Example

Suppose the value loss on external capital is as follows:

$$T(.) = \frac{\gamma}{2}(.)^2 \tag{A.1}$$

The value loss (T) increases as more external capital is raised and the marginal cost is simply γ times the amount raised. Convex costs are justified by an increasing marginal cost of capital schedule as discussed by Hubbard (1998). The value function at period 1 is a simply quadratic function that incorporates the value of the firm's future cash flows and its internal cost of capital,

$$V_t = \beta_0 + \beta_1 I_t - \frac{\beta_2}{2} I_t^2 \tag{A.2}$$

Without external capital the optimal investment is simply

$$\frac{dV_t}{dI_t} = \beta_1 - \beta_2 I_t - 1 = 0 \tag{A.3}$$

or

$$I_t = \frac{\beta_1 - 1}{\beta_2} \tag{A.4}$$

The parameter restrictions on the value function require $\beta_1 > 1, \beta_2 > 0,$ otherwise optimal investment is negative,

With external capital the optimal investment is

$$\frac{dV_t}{dI_t} = \beta_1 - \beta_2 I_t - 1 - \gamma(I_t - (F_{t-1} - I_t)(1+r) - C_t) = 0 \tag{A.5}$$

where $((F_{t-1}-I_t)(1+r)-C_t)$ is the available funds, which for simplicity we denote by A_t. Optimal investment is then

$$I_t^* = \frac{\beta_1 - 1 + \gamma A_t}{(\beta_2 + \gamma)} \tag{A.6}$$

The optimal net present value at time period t is then

$$NPV_t = \beta_0 + \beta_1 I_t^* - \frac{\beta_2}{2}(I_t^*)^2 - (\frac{\gamma}{2})(I_t^* - A_t)^2 - I_t^* \tag{A.7}$$

The net present value of this investment is simply the value function minus the required investment plus any surplus cash and return s from marketable securities. Apart from the return on marketable securities, the properties of the value function are

$$\frac{dNPV_t}{dA_t} = \frac{dNPV_t^*}{dI_t^*}\frac{\gamma}{(\beta_2+\gamma)} + \gamma(I_t^* - A_t) > 0 \tag{A.8}$$

The increased value comes from the second term which is simply the direct effect of the reduction in value loss by raising less external capital plus the first term which comes about from increasing the optimal level of investment. The effect of increased cash flow (*C_t)* on the value function is exactly the same as increased financial slack except for the absence of a return earned from the initial period.

Table A.1 uses specific numbers to illustrate the results where cash flow runs from 0 to 90 which is more than enough to fund the optimal investment. With perfect capital markets (*PCM*) the firm's optimal investment is $80 determined by $\beta_1=1.4$ *and* $\beta_2 = 0.005$. The market value is then $101 and the NPV $21. With no financial slack and no free cash flow all the investment has to be funded from external capital markets, so that with imperfect capital markets (*ICM)* the value loss is γ=0.005. In this case the optimal investment drops to $72.72 with a present value of $92.27 and NPV of $19.55. The drop in NPV is due to the direct value loss from accessing external capital of $0.04 and loss in NPV of $1.42 due to the indirect effects of capital rationing.[7]

Table A.1

	1	2	3	4	5	6	7	8	9	10
Cash flow	0	10	20	30	40	50	60	70	80	90
investment rate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Value loss gamma	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
investment function										
beta0	5	5	5	5	5	5	5	5	5	5
beta1	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
beta2	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Financial slack	0	0	0	0	0	0	0	0	0	0
Initial investment	0	0	0	0	0	0	0	0	0	0
external	0	10	20	30	40	50	60	70	80	90
Surplus	0	0	0	0	0	0	0	0	1.42E-14	10
net gamma	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0	0
available funds	0	10	20	30	40	50	60	70	0	0
optimal investment PCM	80	80	80	80	80	80	80	80	80	80
optimal value	101	101	101	101	101	101	101	101	101	101
market to book	1.2625	1.2625	1.2625	1.2625	1.2625	1.2625	1.2625	1.2625	1.2625	1.2625
NPV	21	21	21	21	21	21	21	21	21	21
optimal investment; ICM	72.7273	73.6364	74.5455	75.4545	76.3636	77.2727	78.1818	79.0909	80.0000	80.0000
Funding	72.7273	63.6364	54.5455	45.4545	36.3636	27.2727	18.1818	9.0909	0.0000	0.0000
optimal value	92.2727	93.5227	94.7273	95.8864	97.0000	98.0682	99.0909	100.0682	101.0000	111.0000
market to book	1.2688	1.2701	1.2707	1.2708	1.2702	1.2691	1.2674	1.2652	1.2625	1.2333
NPV	19.5455	19.8864	20.1818	20.4318	20.6364	20.7955	20.9091	20.9773	21.0000	21.0000

[7] The numbers are purely illustrative.

Note that the table illustrates the classic description of capital rationing: as the internal cash flow increases, the value loss from external capital falls and the firm can undertake more investment. As a result, the NPV increases until with enough cash flow to fund the firm's investment there is no value loss. If internal cash flow exceeds the optimal investment level of $80, the surplus is simply invested or paid out as dividends at the same value. The correlation between investment and cash flow in this example is 0.995 rather than 1.0 due to the fixed level of investment, once the firm has reached the optimal investment level.

In the prior period, the present value of this value function is uncertain since the cash flow at *t* is uncertain and as a result so too is the value loss from external financing. Table A.1 indicates that if the range of the expected cash flow is from 0-$90, the NPV will range from $19.55-$21 as the firm suffers a value loss from being forced to access external capital markets, when there is low internal cash flow. Note also that the concavity of the value function means that the impact of cash flow on the NPV is also concave - that is, there are diminishing returns to cash flow. The example in Table A.1 indicates the costs of inadequate financial slack and cash flow volatility. As the wedge between internal and external capital is increased this value loss increases accordingly, so that financial slack has the most value for firms that face significant financial constraints and also have highly volatile cash flows. In the above table, regardless of the cash flow volatility and severity of the financial constraints, more financial slack reduces the value loss.

TABLE 1

Selected Financial Ratio Medians

(1981 to 1998)

Vol(CF/K) is the standard deviation of cash flow-to-net fixed assets (CF/K) for a firm over the 1981 to 1998 period, while CV(CF/K) is the coefficient of variation of CF/K for the firm over the same period. The TA groups 1, 2 and 3 are groups formed based on firm size as measured by its total assets (TA) in a given year, with TA1 being the smallest third of firms, TA2 being the next biggest third and TA3 being the largest third. The cash flow volatility quartiles are constructed based on the two cash flow volatility measures (Vol (CF/K) and CV(CF/K) respectively.

Panel A: Total Sample Statistics

	Total assets ($)	**Investment/ Net fixed assets (t)**	**Cash flow /Net fixed assets (t) (CF/K)**	**Market-to-book (t-1)**	**Debt ratio (t-1)**	**Current ratio (t-1)**	**Slack (Current ratio / Debt ratio)**	**Net income margin (t-1)**	**Div-to-EBIT**	**Vol (CF/K)**	**CV (CF/K)**
Total Sample	366m	0.19	0.29	1.53	0.23	1.88	7.85	0.046	0.14	0.19	0.43
Size Groups (Based on total assets in a given year)											
TA1 (Small)	45m	0.20	0.33	1.34	0.18	2.45	11.71	0.034	0.00	0.26	0.78
TA2 (Medium)	366m	0.20	0.32	1.62	0.23	2.00	8.66	0.046	0.15	0.18	0.40
TA3 (Large)	3,558m	0.17	0.21	1.60	0.28	1.40	5.38	0.057	0.21	0.15	0.33
Cash Flow Volatility Quartiles (Based on Vol(CF/K): 1 = low volatility; 4 = high volatility)											
Q1Vol(CF/K)	1,684m	0.13	0.13	1.41	0.34	1.14	3.38	0.063	0.25	0.10	0.21
Q2Vol(CF/K)	563m	0.20	0.30	1.62	0.22	1.91	8.63	0.044	0.16	0.16	0.36
Q3Vol(CF/K)	271m	0.22	0.38	1.61	0.19	2.16	10.70	0.042	0.11	0.22	0.53
Q4Vol(CF/K)	78m	0.26	0.51	1.56	0.17	2.44	12.51	0.035	0.00	0.32	1.03
Cash Flow Volatility Quartiles (Based on CV(CF/K): 1 = low volatility; 4 = high volatility)											
Q1CV(CF/K)	1,125m	0.17	0.23	1.63	0.28	1.46	5.40	0.064	0.24	0.11	0.19
Q2CV(CF/K)	692m	0.20	0.32	1.68	0.23	1.88	7.92	0.052	0.18	0.17	0.35
Q3CV(CF/K)	274m	0.21	0.34	1.45	0.22	2.02	9.23	0.039	0.11	0.23	0.56
Q4CV(CF/K)	72m	0.18	0.24	1.30	0.22	2.20	9.16	0.023	0.00	0.32	1.36

Panel B: Sub-Group Statistics

	Debt ratio (t-1)	**Current ratio (t-1)**	**Slack (Current ratio / Debt ratio)**	**Debt ratio (t-1)**	**Current ratio (t-1)**	**Slack (Current ratio / Debt ratio)**	**Debt ratio (t-1)**	**Current ratio (t-1)**	**Slack (Current ratio / Debt ratio)**
	TA3 (Big) Group			**TA2 (Medium) Group**			**TA1 (Small) Group**		
VolCF Quartiles									
Q1Vol(CF/K)	0.35	1.11	3.26	0.33	1.26	3.65	0.33	1.11	3.16
Q2Vol(CF/K)	0.24	1.55	6.84	0.20	2.04	9.83	0.19	2.46	11.46
Q3Vol(CF/K)	0.21	1.75	8.84	0.20	2.25	10.99	0.17	2.49	12.79
Q4Vol(CF/K)	0.17	1.99	11.80	0.17	2.31	11.96	0.16	2.57	12.86
CVCF Quartiles									
Q1CV(CF/K)	0.31	1.26	4.44	0.27	1.69	6.69	0.16	2.21	10.87
Q2CV(CF/K)	0.27	1.38	5.46	0.20	2.07	9.94	0.16	2.82	14.76
Q3CV(CF/K)	0.25	1.56	6.47	0.21	2.15	10.10	0.19	2.40	11.22
Q4CV(CF/K)	0.26	1.66	6.45	0.27	2.07	7.92	0.19	2.38	11.04

TABLE 2

Group Comparison Tests

This table presents the results of non-parametric tests of sub-sample "location" in Panel A, and tests of sub-sample mean equality in Panel B. The TA groups 1, 2 and 3 are groups formed based on firm size as measured by its total assets (TA) in a given year, with TA1 being the smallest third of firms, TA2 being the next biggest third and TA3 being the largest third. The cash flow volatility quartiles are constructed based on the two cash flow volatility measures (Vol (CF/K) and CV(CF/K) respectively. Q1 has the lowest volatility. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Panel A: Mann-Whitney Tests

The Mann-Whitney test compares the "location" of two independent samples, based on the null hypothesis that they have the same location. It is a non-parametric test that assumes that the two independent population distributions are continuous and have the same shape; although they may differ in location. The resulting test statistic (Z) reported below follows approximately a standard normal distribution. The significance level is reported in parentheses.

	Debt ratio (t-1)	**Current ratio (t-1)**	**Slack (Current ratio / Debt ratio)**
Size Groups			
TA1 versus TA2	-14.5 (0.000)***	24.0 (0.000)***	14.4 (0.000)***
TA1 versus TA3	-30.7 (0.000)***	56.5 (0.000)***	40.1 (0.000)***
TA2 versus TA3	-17.7 (0.000)***	39.0 (0.000)***	28.1 (0.000)***
Vol(CF/K) Quartiles			
Q1Vol(CF/K) versus Q2Vol(CF/K)	39.7 (0.000)***	-48.0 (0.000)***	-49.7 (0.000)***
Q1Vol(CF/K) versus Q3Vol(CF/K)	42.2 (0.000)***	-57.1 (0.000)***	-55.8 (0.000)***
Q1Vol(CF/K) versus Q4Vol(CF/K)	41.2 (0.000)***	-60.9 (0.000)***	-55.6 (0.000)***
Q2Vol(CF/K) versus Q4Vol(CF/K)	12.1 (0.000)***	-24.1 (0.000)***	-16.4 (0.000)***
Q3Vol(CF/K) versus Q4Vol(CF/K)	6.5 (0.000)***	-11.2 (0.000)***	-6.9 (0.000)***
Q2Vol(CF/K) versus Q3Vol(CF/K)	6.4 (0.000)***	-14.3 (0.000)***	-10.7 (0.000)***
CV(CF/K) Quartiles			
Q1CV(CF/K) versus Q2CV(CF/K)	11.6 (0.000)***	-20.5 (0.000)***	-17.1 (0.000)***
Q1CV(CF/K) versus Q3CV(CF/K)	13.3 (0.000)***	-30.3 (0.000)***	-24.1 (0.000)***
Q1CV(CF/K) versus Q4CV(CF/K)	11.1 (0.000)***	-35.2 (0.000)***	-22.7 (0.000)***
Q2CV(CF/K) versus Q4CV(CF/K)	1.6 (0.112)	-16.3 (0.000)***	-6.8 (0.000)***
Q3CV(CF/K) versus Q4CV(CF/K)	0.5 (0.614)	-7.4 (0.000)***	-0.0 (0.977)
Q2CV(CF/K) versus Q3CV(CF/K)	2.7 (0.008)***	-9.7 (0.000)***	-7.2 (0.000)***

Panel B: Means Equality T-Tests

T-statistics are reported below based on the null hypothesis that the groups have the same mean.
The significance level is reported in parentheses.

	Debt ratio (t-1)	Current ratio (t-1)	Slack (Current ratio / Debt ratio)
Size Groups			
TA1 versus TA2	-9.6 (0.000)***	4.8 (0.000)***	6.5 (0.000)***
TA1 versus TA3	-24.5 (0.000)***	6.8 (0.000)***	11.6 (0.000)***
TA2 versus TA3	-16.7 (0.000)***	37.7 (0.000)***	7.6 (0.000)***
Vol(CF/K) Quartiles			
Q1Vol(CF/K) versus Q2Vol(CF/K)	40.1 (0.000)***	-36.8 (0.000)***	-10.0 (0.000)***
Q1Vol(CF/K) versus Q3Vol(CF/K)	42.1 (0.000)***	-26.1 (0.000)***	-10.4 (0.000)***
Q1Vol(CF/K) versus Q4Vol(CF/K)	34.3 (0.000)***	-5.8 (0.000)***	-11.5 (0.000)***
Q2Vol(CF/K) versus Q4Vol(CF/K)	4.1 (0.000)***	-3.8 (0.000)***	-8.3 (0.000)***
Q3Vol(CF/K) versus Q4Vol(CF/K)	0.6 (0.535)***	-2.5 (0.000)***	-6.1 (0.000)***
Q2Vol(CF/K) versus Q3Vol(CF/K)	4.2 (0.000)***	-10.3 (0.000)***	-3.6 (0.000)***
CV(CF/K) Quartiles			
Q1CV(CF/K) versus Q2CV(CF/K)	10.3 (0.000)***	-16.3 (0.000)***	-4.5 (0.000)***
Q1CV(CF/K) versus Q3CV(CF/K)	9.9 (0.000)***	-23.6 (0.000)***	-4.1 (0.000)***
Q1CV(CF/K) versus Q4CV(CF/K)	4.7 (0.000)***	-4.6 (0.000)***	-7.9 (0.000)***
Q2CV(CF/K) versus Q4CV(CF/K)	-3.3 (0.001)***	-3.3 (0.001)***	-5.3 (0.000)***
Q3CV(CF/K) versus Q4CV(CF/K)	-3.3 (0.001)***	-2.8 (0.006)***	0.5 (0.618)
Q2CV(CF/K) versus Q3CV(CF/K)	0.3 (0.784)	-5.7 (0.000)***	-7.2 (0.000)***

Table 3

Regression Estimates (Total Sample)

The reported values are fixed effects (within) regression estimates over the 1981-98 sample period. T-statistics are in parentheses. Capital expenditures divided by net fixed assets (I/K) is the dependent variable. The firm's market-to-book ratio (M/B), and cash flow/net fixed assets (CF/K) are the independent variables. The sub-groups include all firm-year observations that are included in three groups, which are defined below. The TA groups 1, 2 and 3 are groups formed based on firm size as measured by its total assets (TA) in a given year, with TA1 being the smallest third of firms, TA2 being the next biggest third and TA3 being the largest third. The cash flow volatility quartiles are constructed based on the two cash flow volatility measures (Vol (CF/K) and CV(CF/K) respectively. The slack quartiles are constructed based on the slack (current ratio/debt ratio), while the debt quartiles are based on the debt ratios, and the current quartiles are based on current ratios).

Panel A: Regression Estimates

Group	M/B		CF		Adj. R^2	'n'
Total Sample	0.026	(14.8)	0.178	(36.3)	7.9%	20,394
Size (TA) Groups						
TA1 (Small)	0.036	(11.1)	0.136	(19.5)	7.7%	6786
TA2	0.023	(7.2)	0.235	(22.0)	8.7%	6822
TA3 (Big)	0.004	(1.5)	0.500	(33.9)	15.1%	6786
Vol (CF/K) Groups						
Quartile 1 (Low Volatility)	0.000	(0.1)	0.654	(19.5)	7.2%	5094
Quartile 2	-0.000	(-0.0)	0.632	(24.7)	11.3%	5094
Quartile 3	0.021	(5.9)	0.535	(23.7)	12.8%	5094
Quartile 4 (High Volatility)	0.033	(8.0)	0.150	(19.3)	8.8%	5112
CV (CF/K) Groups						
Quartile 1 (Low Volatility)	-0.005	(-2.2)	0.541	(24.6)	10.9%	5094
Quartile 2	0.003	(0.9)	0.384	(20.9)	9.1%	5094
Quartile 3	0.027	(6.4)	0.286	(25.3)	13.6%	5094
Quartile 4 (High Volatility)	0.034	(9.0)	0.139	(16.2)	6.9%	5112

Panel B: Cross-Dummy T-Statistics

This panel presents t-statistics estimated on cross-dummy variable coefficients. The cross-dummy variables are constructed by multiplying the independent variables (M/B and CF/K) by the respective sub-group dummy variable. Regressions are run with the sub-group dummy variable included, and with the cross-dummy variables. If the two sub-groups have the same coefficient on the respective independent variable (i.e., M/B or CF/K), the cross-dummy variable will be insignificant. If the cross dummies are significant it indicates that the coefficient estimates differ significantly across the two sub-groups. For each regression, the dummy variable included equals 1 if the observation is from the first sub-group listed, and 0 if it is from the second sub-group.
* denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Groups	**M/B × Sub-Group Dummy**	**CF × Sub-Group Dummy**
Size (TA) Groups		
TA1 versus TA2	1.8*	-3.7***
TA1 versus TA3	4.4***	-7.3***
TA2 versus TA3	3.2***	-6.6***
QVol(CF/K) Groups		
QVolCF1 versus QVolCF2	-2.1**	5.2***
QVolCF1 versus QVolCF3	-4.3***	5.2***
QVolCF1 versus QVolCF4	-4.2***	4.9***
QVolCF2 versus QVolCF4	-4.6***	7.1***
QVolCF3 versus QVolCF4	-2.7***	9.3***
QVolCF2 versus QVolCF3	-3.7***	3.7***
QCV(CF/K) Groups		
QCVCF1 versus QCVCF2	-1.9*	3.1***
QCVCF1 versus QCVCF3	-4.5***	4.4***
QCVCF1 versus QCVCF4	-4.4***	4.1***
QCVCF2 versus QCVCF4	-3.5***	4.3***
QCVCF3 versus QCVCF4	-0.7	5.3***
QCVCF2 versus QCVCF3	-3.1***	2.8***

Table 4

Regression Estimates for Size (TA) Sub-Groups

The reported values are fixed effects (within) regression estimates over the 1981-98 sample period. T-statistics are in parentheses. Capital expenditures divided by net fixed assets (I/K) is the dependent variable. The firm's market-to-book ratio (M/B), and cash flow/net fixed assets (CF/K) are the independent variables. The sub-groups include all firm-year observations that are included in three groups, which are defined below. The TA groups 1, 2 and 3 are groups formed based on firm size as measured by its total assets (TA) in a given year, with TA1 being the smallest third of firms, TA2 being the next biggest third and TA3 being the largest third. The cash flow volatility quartiles are constructed based on the two cash flow volatility measures (Vol (CF/K) and CV(CF/K) respectively. The slack quartiles are constructed based on the slack (current ratio/debt ratio), while the debt quartiles are based on the debt ratios, and the current quartiles are based on current ratios).

Panel A: Regression Estimates

Group	M/B		CF		Adj. R^2	'n'
TA3 Group (Big)	0.004	(1.5)	0.500	(33.9)	15.1%	6786
Vol (CF/K) Sub-Groups (Within TA3 Group)						
Quartile 1 (Low Volatility)	-0.007	(-1.7)	0.730	(15.0)	6.8%	3085
Quartile 2	-0.009	(-2.5)	0.697	(15.9)	11.4%	1981
Quartile 3	0.015	(2.2)	0.547	(10.1)	10.2%	1198
Quartile 4 (High Volatility)	0.010	(0.8)	0.454	(13.7)	27.1%	522
Vol (CF/K) Sub-Groups (Within TA3 Group)						
Quartile 1 (Low Volatility)	-0.010	(-4.1)	0.537	(17.1)	10.1%	2611
Quartile 2	-0.007	(-1.6)	0.413	(11.5)	6.2%	2093
Quartile 3	0.037	(4.1)	0.416	(17.2)	19.2%	1468
Quartile 4 (High Volatility)	0.014	(1.5)	0.721	(12.1)	20.0%	614
TA2 Group (Medium)	0.023	(7.2)	0.235	(22.0)	8.7%	6822
Vol (CF/K) Sub-Groups (Within TA2 Group)						
Quartile 1 (Low Volatility)	0.013	(2.6)	0.565	(10.5)	7.5%	1611
Quartile 2	0.005	(1.0)	0.647	(14.6)	12.1%	1769
Quartile 3	0.015	(2.2)	0.611	(17.3)	15.2%	2077
Quartile 4 (High Volatility)	0.020	(2.9)	0.169	(10.2)	8.8%	1365
CV (CF/K) Sub-Groups (Within TA2 Group)						
Quartile 1 (Low Volatility)	0.004	(1.0)	0.565	(15.5)	12.7%	1914
Quartile 2	0.013	(2.4)	0.357	(12.5)	10.0%	1895
Quartile 3	0.017	(2.4)	0.237	(11.8)	8.8%	1818
Quartile 4 (High Volatility)	0.033	(4.0)	0.203	(8.9)	8.5%	1195
TA1 Group (Small)	0.036	(11.1)	0.136	(19.5)	7.7%	6786
Vol (CF/K) Sub-Groups (Within TA1 Group)						
Quartile 1 (Low Volatility)	0.006	(1.0)	0.826	(7.4)	12.3%	398
Quartile 2	0.012	(2.7)	0.528	(11.9)	11.2%	1344
Quartile 3	0.031	(5.5)	0.450	(13.2)	12.1%	1819
Quartile 4 (High Volatility)	0.039	(7.5)	0.125	(13.7)	7.9%	3225
CV (CF/K) Sub-Groups (Within TA1 Group)						
Quartile 1 (Low Volatility)	0.004	(0.5)	0.424	(7.1)	8.8%	569
Quartile 2	0.012	(1.9)	0.379	(11.8)	13.8%	1106
Quartile 3	0.031	(5.1)	0.262	(16.0)	15.4%	1808
Quartile 4 (High Volatility)	0.037	(7.8)	0.116	(12.3)	6.6%	3303

Panel B: Cross-Dummy T-Statistics for Size (TA) Sub-Groups

This panel presents t-statistics estimated on cross-dummy variable coefficients. The cross-dummy variables are constructed by multiplying the independent variables (M/B and CF/K) by the respective sub-group dummy variable. Regressions are run with the sub-group dummy variable included, and with the cross-dummy variables. If the two sub-groups have the same coefficient on the respective independent variable (i.e., M/B or CF/K), the cross-dummy variable will be insignificant. If the cross dummies are significant it indicates that the coefficient estimates differ significantly across the two sub-groups. For each regression, the dummy variable included equals 1 if the observation is from the first sub-group listed, and 0 if it is from the second sub-group.
* denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Groups	M/B × Sub-Group Dummy	CF × Sub-Group Dummy
Vol (CF/K) Sub-Groups (Within TA3 Group)		
QVolCF1 versus QVolCF2	-2.5**	4.6***
QVolCF1 versus QVolCF3	-4.4***	5.2***
QVolCF1 versus QVolCF4	-3.8***	5.1***
QVolCF2 versus QVolCF4	-2.2**	3.1***
QVolCF3 versus QVolCF4	-0.5	1.0
QVolCF2 versus QVolCF3	-3.0***	2.6**
CV (CF/K) Sub-Groups (Within TA3 Group)		
QCVCF1 versus QCVCF2	-1.3	2.1**
QCVCF1 versus QCVCF3	-4.2***	3.5***
QCVCF1 versus QCVCF4	-2.8***	1.5
QCVCF2 versus QCVCF4	-1.8*	-0.5
QCVCF3 versus QCVCF4	1.6	-3.2***
QCVCF2 versus QCVCF3	-2.9***	1.6
Vol (CF/K) Sub-Groups (Within TA2 Group)		
QVolCF1 versus QVolCF2	-0.7	2.4**
QVolCF1 versus QVolCF3	-1.0	1.9 *
QVolCF1 versus QVolCF4	-1.0	2.4**
QVolCF2 versus QVolCF4	-0.9	4.6***
QVolCF3 versus QVolCF4	-2.0**	6.9***
QVolCF2 versus QVolCF3	-0.7	1.5
CV (CF/K) Sub-Groups (Within TA2 Group)		
QCVCF1 versus QCVCF2	-0.8	2.1**
QCVCF1 versus QCVCF3	-1.1	2.2**
QCVCF1 versus QCVCF4	-2.1**	2.5**
QCVCF2 versus QCVCF4	-1.6	3.2***
QCVCF3 versus QCVCF4	-0.9	-0.3
QCVCF2 versus QCVCF3	-0.6	3.0***
Vol (CF/K) Sub-Groups (Within TA1 Group)		
QVolCF1 versus QVolCF2	0.4	1.9*
QVolCF1 versus QVolCF3	-0.9	1.2
QVolCF1 versus QVolCF4	-0.8	0.8
QVolCF2 versus QVolCF4	-1.9*	2.8***
QVolCF3 versus QVolCF4	-0.8	4.8***
QVolCF2 versus QVolCF3	-2.2**	1.7*
CV (CF/K) Sub-Groups (Within TA1 Group)		
QCVCF1 versus QCVCF2	-1.4	0.8
QCVCF1 versus QCVCF3	-1.4	0.9
QCVCF1 versus QCVCF4	-0.9	0.7
QCVCF2 versus QCVCF4	-1.3	1.6
QCVCF3 versus QCVCF4	-0.6	4.2***
QCVCF2 versus QCVCF3	-1.5	0.7