Investment and Financing Constraints

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We investigate whether the sensitivity of corporate investment to internal cash flows is related to financing constraints. Besides financing constraints, measurement error in Tobin's q is another competing explanation for the sensitivity, suggested in the literature. Controlling for measurement errors in Tobin's q and using a parsimonious model specification, we find that investment-cash flow sensitivities are positive and vary with financing constraints. Measurement errors in Tobin's q do not explain away the sensitivities for firms facing financing constraints. Evidence of this first-order linear relationship between investment and internal funds are consistent with the larger literature documenting the effects of financing frictions on investment.

INTRODUCTION

Studying the effect of financing constraints on firms' investment behavior represents a core interest of researchers and policymakers in finance and economics. Accordingly, there is a large literature on the sensitivity of firms' investments to their internal funds.[1] In their seminal paper, Fazzari, Hubbard, and Petersen (1988) hypothesize that more-constrained firms should rely more heavily on internal cash flows to finance investment. With a wedge to financing externally, a constrained firm benefiting from cash inflows finds itself with the ability to invest more. When regressing investment-to-capital on Tobin's *q* and cash flow-to-capital, and identifying more-constrained firms as low-dividend payers, Fazzari, Hubbard, and Petersen (1988) find that larger investment-cash flow sensitivities indicate more binding financing constraints.

This area of research has been a fertile ground for debate, in part because Tobin's marginal *q* is not observable. In a comment to the Fazzari, Hubbard, and Petersen's (1988) article, Poterba (1988) introduces the idea that errors in measuring Tobin's *q*, not financing constraints, may be responsible for the observed investment-cash flow sensitivities. If cash flow were correlated with investment opportunities not well measured by the proxy for Tobin's *q*, investment-cash flow sensitivities could arise. In an influential paper, Erickson and Whited (2000) directly address the issue by developing measurement error-consistent generalized method of moments (GMM) estimators. In their empirical tests, investment-cash flow sensitivities are no longer statistically significant when controlling for measurement errors in Tobin's *q*.

The irrelevance of cash flow for investment, reported in Erickson and Whited (2000), has cast doubts on the validity of extensive evidence obtained from traditional investment-cash flow sensitivity estimations in the past. Sorting out the investment-cash flow sensitivity results is important because it relates to the larger macroeconomic effects of financing frictions. It is well-known that financing frictions, through their effect on investment, can slow down economic growth and amplify business cycles. These effects are documented in Aghion, Banerjee, and Piketty (1999), Banerjee and Newman (1993), Bernanke and Gertler (1989), Holmstrom and Tirole (1998), King and Levine (1993), Kiyotaki and Moore (1997), and Obstfeld (1994), among others.

This study follows the approach adopted by Fazarri, Hubbard, and Petersen (1988), Kaplan and Zingales (1997), and a number of subsequent empirical studies, by classifying firms according to their financing status and estimating the investment-cash flow sensitivity for different groups of firms. In our tests we employ the measurement error-consistent GMM estimators suggested by Erickson and Whited (2000). While the effect of financing constraints on investment can be detected using more sophisticated empirical strategies, investment-cash flow sensitivities nevertheless capture the linear, first-order reduced form relationship between investment and internal cash flows. Useful advantage of this approach is that it allows for direct comparison with previous studies.

The result, that investment-cash flow sensitivities disappear once measurement error in Tobin's q is taken into account, is obtained from an untraditional specification that restricts the coefficient on Tobin's q to be identical for firms with differential financing status. The restriction is not necessarily supported in the data and we can decrease the risk of model misspecification by adopting a more parsimonious specification allowing firms with different financing status to have different sensitivity of investment to Tobin's q. In fact, the majority of earlier studies on the sensitivity of investment to internal funds have employed more flexible specifications allowing firms with different financing status to have different sensitivity of investment to Tobin's q. We investigate whether cash flow remains irrelevant for investment when we control for measurement error in Tobin's q and allow firms with different financing status to have different sensitivity of investment to Tobin's q. We find that, if we impose the restriction, we obtain Erickson and Whited's (2000) result that cash flow is irrelevant for investment regardless of the financing status of the firm. However, if we relax the restriction, investment exhibits strong positive association with cash flow for firms identified as financially more-constrained even after measurement error in Tobin's q is controlled for. These results confirm the findings in Fazarri, Hubbard, and Petersen (1988), and a number of subsequent studies, that investment decisions of firms facing financing frictions are sensitive to the availability of internal funds because they have a cost advantage over external financing.

Another debate arose earlier in the investment-cash flow sensitivity literature because financing constraints are not observable. Different proxies for financing constraints yield different conclusions on how financing constraints affect the investment-cash flow sensitivity. Identifying more-constrained firms using information extracted from company annual reports, Kaplan and Zingales (1997) obtain a different result: larger investment-cash flow sensitivities are associated with *less* binding financing constraints.[2] To address this concern, we use a variety of proxies for financing constraints to test the robustness of our results. Two of the proxies, firm size and the presence of credit rating, are based on a single variable, while the other two, Cleary's (1999) financing constraints index and Whited and Wu's (2006) financing constraints index, attempt to capture multiple aspects of a firm's financing status. Having obtained investment-cash flow sensitivity estimates for firms of differential financing status, we contribute to the debate on the effect of financing constraints on the sensitivity of investment to cash flow by providing evidence from measurement error-consistent estimations. We find that financially more-constrained firms exhibit larger investment-cash flow sensitivity than firms identified as financially less-constrained. These results are consistent with the findings of a number of previous studies that do not explicitly control for measurement error in Tobin's q.

The next section discusses a simple Tobin's q model of investment augmented with financing constraints and presents the regression specification along with the proxies for financing constraints. Section 3 describes the sample and variable construction, while section 4 reports the empirical results. Section 5 concludes.

REGRESSION SPECIFICATION

The majority of studies on the effect of financing constraints on firm investment are based on the q-theory of investment, where marginal q represents the shadow value of an additional unit of capital. In a frictionless environment a value-maximizing firm will invest as long as the shadow value of an additional unit of capital exceeds its replacement cost, or in other words, until marginal q exceeds one. The appealing feature of this framework is that marginal q summarizes the market evaluation of the investment opportunities of the firm. The difficulty to take the model to the data comes from the fact that marginal q is not directly observable. Hayashi (1982) shows that under specific conditions, constant returns to scale and perfect competition, marginal q equals average Q, which is the market value of a unit of existing capital stock divided by its replacement value. The investment-Tobin's q specification is derived from the first-order condition to the inter-temporal value-maximization problem of the firm augmented with convex adjustment costs. The first order condition expresses the investment-to-capital ratio as a linear function of marginal q. Fazzari, Hubbard, and Petersen (1988) propose a regression specification based on Tobin's marginal q model of investment augmented with convex capital adjustment costs:

$$\frac{I_{it}}{K_{it}} = \boldsymbol{z_{it}}\alpha + \beta Q_{it} + u_{it} \tag{1}$$

where marginal q is proxied by the beginning-of-the period average Q and an error term, I_{it} represents firm i's investment in period t, K_{it} represents its beginning-of-period t capital stock, and the row vector $\boldsymbol{z_{it}}$ allows the inclusion of additional explanatory variables.

The majority of the contemporary empirical studies, applied on panel data, have adopted the strategy to split the sample into two, or more, mutually exclusive groups with respect to the degree of financing constraints. In these studies the vector $\boldsymbol{z_{it}}$ typically contains a liquidity variable (e.g. cash flow) and a constant, as in the following specification which is estimated separately for each of the groups of firms[3]:

$$\frac{I_{it}}{K_{it}} = \gamma_0 + \gamma_1 \frac{CF_{it}}{K_{it}} + \beta Q_{it} + \varepsilon_{it} \tag{2}$$

Estimating the specification in (2) for each group yields group-specific estimates and allows testing for significant differences between these estimates.

The intuition behind including a liquidity variable in the specification, i.e. cash flow, relates to its ability to relax binding financing constraints. A firm that is not financially constrained is indifferent between using internal or external sources of financing since there is no difference in the cost of the funds. Such firm has the freedom to optimally adjust its investment according to its investment opportunities. Therefore, the cash flow generated by a firm facing no financing constraints is not expected to affect its investment decisions after we control for investment opportunities. On the other hand, a financially constrained firm facing higher cost of external financing, or suffering from capital rationing, is not indifferent to the source of financing and prefers the use of less expensive internal funds to using more expensive external funds. If such a firm generates larger cash flow in a period it will be able to invest more and vice versa. The wedge in the cost of internal and external financing makes internal funds the first choice of financing and generates a positive relationship between investment and internal funds. The first hypothesis we test for each of the groups is: $H_0 : \gamma_1 = 0$. Firms facing no financing constraints are hypothesized to exhibit γ_1 close to zero and firms that are financially constrained are hypothesized to exhibit a positive sensitivity of investment to cash flow, or $\gamma_1 > 0$.

Erickson and Whited (2000) report that estimation of (2) is not applicable to their sample since their split-sample models cannot be reliably estimated due to poor identification in either the less-constrained or the more-constrained groups of firms. They offer an alternative specification including a dummy variable ($\mathrm{d_{it}}$) and its interactions with a cash flow term to obtain group-specific estimates for the sensitivities of investment to cash flow. Erickson and Whited (2000) use the full sample, pooling more-constrained and less-constrained firms together, to estimate the specification:

$$\frac{I_{it}}{K_{it}} = \alpha_0 + \alpha_1 \frac{CF_{it}}{K_{it}} + \alpha_2 d_{it} \frac{CF_{it}}{K_{it}} + \alpha_3 d_{it} + \beta Q_{it} + \epsilon_{it} \quad (3)$$

where (d_{it}) equals one if the firm belongs to the more-constrained group and equals zero otherwise. An important difference between the two specifications is that the interaction term specification in (3) is restricting β to be identical for firms of differential financing status, while the split-sample approach in (2) does not impose such restriction. Next, we turn to the specifics of identifying financially more-constrained and less-constrained firms.

Because financing constraints are not directly observable, we resort to the use of proxies to measure a firm's financing status. Two types of proxies have been predominantly used in the previous empirical work. The first type of proxies are based on a single variable, including the dividend payout ratio, firm size, or the presence of a credit rating. Proxies of the second type are based on an index reflecting multiple aspects of the company's financing status, including Kaplan and Zingales's (1997) *KZ* index, Cleary's (1999) Z_{FC} index, or Whited and Wu's (2006) WW index. To demonstrate the robustness of our results, we use two single-variable measures and two indices. The two single-variable measures we use are firm size and the presence of credit rating. The advantage of these two measures is that they are likely to be exogenous to the firms' investment decisions, while the dividend payout may not be. The two index measures we use are from Cleary (1999) and Whited and Wu (2006). The *K Z* index is based on Tobin's q, which may be associated with measurement errors.

Small firms are typically viewed as more likely to face information asymmetries and thus be financially constrained. We measure firm size by the book value of total assets and the replacement value of capital stock. Following Erickson and Whited (2000) we rank firms in any particular cross-section according to their book value of total assets and according to the replacement value of their capital stock. Firms in the lower one third of the distribution of total assets and in the lower one third of the distribution of capital stock are classified as *more-constrained*, while all others are classified as *less-constrained*.

To explore the robustness of our results and to allow for comparison with previous studies we also use the presence of a credit rating as a single-variable proxy for a firm's financing status. Firms with a credit rating are viewed as less likely to be financially constrained. We should note that the presence of a credit rating, suffers from a major drawback in identifying financially constrained firms. The presence of a rating is a reliable signal for an easier access to financial markets, but the absence of a credit rating does not necessarily assure that a firm is financially constrained. It is not rare for companies in a good financial standing to intentionally choose low levels of debt financing, or no debt at all, and thus forgo any possibility to receive a credit rating. Therefore, the presence of credit rating is successful in identifying firms facing little or no financing constraints, but it is a poor criterion to identify firms likely to face considerable financing constraints. A possible consequence to using the presence of a credit rating as a proxy would be the combination of firms with quite differential financing status into the group of firms without rating. For the purpose of our empirical tests we classify firms as less-constrained if a firm in a particular year has a credit rating reported in COMPUSTAT (*S&P Long Term or S&P Short Term Domestic Issuer Credit Rating,* or its subordinated debt is granted a rating by *S&P*). All other firm-year observations are classified as *more-constrained*. In subsequent tests we use the presence of a credit rating in combination with each one of the other proxies to test the robustness of our results.

We compute Cleary's (1999) index based on the estimation of a probit model of firms' decisions to increase dividends, as described in the appendix. Firms are assumed to increase dividends only when they are in a good financial standing and expect to remain so in the near future. Therefore, the higher the Z_{FC} index values, the less likely it is that the firm is facing financing constraints. We compute the index for each firm-year observation in our sample and rank firms in each cross section by their beginning-of-the-period index values. Firms with Z_{FC} index values in the higher half of the distribution are identified as *less-constrained*, while firms with index values in the lower half are identified as *more-constrained*.

Whited and Wu's (2006) index (WW) is derived from a generalized method of moments estimation of an investment Euler equation, as described in details in the appendix. It represents the Lagrange multiplier on the external financing constraint, or in other words, the shadow cost of external financing. Whited and Wu (2006) specify it as a function of observable firm characteristics and estimate the parameters. High values of the WW index are associated with firms more likely to be financially constrained and facing higher costs of external financing. We compute the WW index for each observation in our sample and rank firms in each cross section by their index values. The firms with WW index values in the lower half of the distribution are identified as *less-constrained*, while firms with index values in the higher half are identified as *more-constrained*.

We use each of the four proxies to split our sample into a group of more-constrained and a group of *less-constrained* firm-year observations and estimate the specification in (2) for each group separately. In the next section we turn to describe our data and the construction of regressions variables.

SAMPLE AND CONSTRUCTION OF VARIABLES

We use data from the COMPUSTAT Industrial Annual files from the period of 1990 to 2004.[4] The majority of the existing studies on the effect of internal funds on investments focus on manufacturing firms and we follow this practice to facilitate comparison. Firms must have non-missing values for the regression variables to be included in the sample. To assure that we exclude records with unreasonable values we require firms in the sample to have positive values for Total Assets (COMPUSTAT mnemonic *at*), Sales (*sale*), and Tobin's q, as well as Tobin's q of no more than fifty. Following Gilchrist and Himmelberg (1995) and Almeida and Campello (2007), we also eliminate very small firms for which Net Property, Plant, and Equipment (*ppent*) is less than two million dollars. Finally, we remove firms with single observations in the sample. We are left with a sample of 22,195 observations from 3,047 firms.

We perform two types of estimations: using ordinary least squares (OLS), and using Erickson and Whited's (2000) measurement error-consistent generalized method of moments estimators utilizing up to third- (GMM3), fourth- (GMM4), and fifth-order (GMM5) moments. The measurement error-consistent estimators are cross-sectional estimators, and are therefore applied to each cross-section of the sample period. In the previous literature there are two established approaches for summarizing the cross section-specific estimates. The first approach is the one suggested by Fama and MacBeth (1973) and applied in an investment-Tobin's q framework in Whited and Bakke (2010). One advantage of this approach is its applicability to unbalanced panels of data and thus preserving valuable information contained in firms with less-than-full record for the sample period. The second approach, demonstrated by Erickson and Whited (2000), is to use minimum distance estimation, which is asymptotically more efficient than any of the individual cross-section estimates. The minimum distance estimator allows for serial correlation in the measurement errors, but requires the use of a balanced panel which, if applied to a longer sample period, might introduce survivorship bias. We employ both of these approaches in our subsequent empirical tests.

In the construction of the regression variables we follow Erickson and Whited (2000). Investment is defined as Capital Expenditures (*capx*) divided by the beginning-of-the-period replacement value of capital stock. Cash flow is the sum of Income before Extraordinary Items (*ib*) and Depreciation and Amortization (*dp*) divided by the beginning-of-the-period replacement value of capital stock. Tobin's average Q is the sum of the market value estimates of common stock, preferred stock, and debt minus the replacement value of inventory, all divided by the beginning-of-the-period replacement value of capital stock. We test the robustness of our results using an alternative construction of the regression variables defining them as in Whited and Bakke (2010). The appendix provides details on variable construction.

Table 1 presents summary statistics for three groups of variables. The first group consists of the regression variables: investment I/K, cash flow CF/K, and Tobin's average Q. The second group consists of proxies for financing constraints: firm size, measured by Total Assets, and the replacement value of capital stock, Cleary's (1999) Z_{FC} index, and Whited and Wu's (2006) *WW* index. Finally, we present summary statistics for the ratio of Long-term Debt-to-Total Assets. Variables are first averaged within each firm and then the average for the median firm is reported. As shown in Table 1, the different proxies for financing constraints do not identify the same firms as *more-constrained*. Each one of the proxies captures different aspects of the firm characteristics contributing to larger informational asymmetries and thus more binding financing constraints.

TABLE 1
SUMMARY STATISTICS

		Financing status measured using:			
		Firm size		Credit rating	
	All firms	More constrained	Less constrained	More constrained	Less constrained
Number of observations	22,195	6,115	16,080	16,005	6,190
(*I/K*)	0.226	0.258	0.220	0.241	0.184
(*CF/K*)	0.222	0.128	0.258	0.220	0.247
Tobin's *Q*	4.606	7.331	3.867	4.908	3.619
Total Asstes ($MM)	159.148	39.711	344.643	112.350	1638.547
Capital Stock ($MM)	34.026	7.266	80.760	22.993	427.210
Z_{FC} index	0.346	0.208	0.389	0.347	0.365
WW index	-0.196	-0.115	-0.247	-0.177	-0.327
LT Debt-to-Total Assets	0.185	0.109	0.211	0.148	0.285
		Financing status measured using:			
		Z_{FC} index		*WW* index	
		More constrained	Less constrained	More constrained	Less constrained
Number of observations		9,918	9,928	11,020	11,025
(*I/K*)		0.163	0.257	0.249	0.206
(*CF/K*)		0.134	0.348	0.134	0.318
Tobin's *Q*		2.969	4.910	2.275	3.564
Total Assets ($MM)		142.870	215.573	74.504	614.208
Capital Stock ($MM)		32.008	47.408	15.213	146.670
Z_{FC} index		0.239	0.480	0.213	0.460
WW index		-0.188	-0.221	-0.148	-0.259
LT Debt-to-Total Assets		0.236	0.159	0.153	0.214

Summary statistics are presented for investment (*I/K*), cash flow (*CF/K*), Tobin's average *Q*, Total Assets, Capital Stock, measured at its replacement value, Cleary's (1999) (Z_{FC}) financing constraints index, Whited and Wu's (2006) (*WW*) financing constraints index, and the Long-Term Debt-to-Total Assets ratio. Observations are first averaged within each firm and the average for the median firm is reported.

RESULTS

We start our empirical tests considering the combined-sample specification of Erickson and Whited (2000), outlined in (3) above and estimated in a balanced panel. To facilitate comparison of results we select the same time period and use the same criteria to identify financially constrained firms. Table 2 reports results from one OLS and three GMM minimum distance estimations. The presence of a credit rating is the criterion for identifying financially constrained firms in panel A, while firm size is the criterion used in panel B. For comparison we reproduce, on the right-hand side of the table, the corresponding results reported in Erickson and Whited (2000). Our results are qualitatively the same as those reported by Erickson and Whited (2000), in Tables 2 to 5, for the credit rating model, as well as those reported in Table 8, for the firm size model. Moreover, our results fall quantitatively very close to those reported by Erickson and Whited (2000) in both models.

TABLE 2
COMBINED-SAMPLE REGRESSION RESULTS, 1992-1995

Panel A	Credit rating interaction model				Erickson and Whited (2000), Tables 2-5			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q* (β)	0.015** (0.001)	0.044** (0.005)	0.032** (0.003)	0.035** (0.002)	0.014** (0.002)	0.045** (0.006)	0.034** (0.005)	0.033** (0.005)
	Less constrained firms							
CF/K (α_1)	0.138** (0.017)	-0.029 (0.036)	0.014 (0.024)	0.044 (0.025)	0.392** (0.061)	-0.041 (0.123)	0.105 (0.098)	0.100 (0.093)
	More constrained firms							
CF/K ($\alpha_1+\alpha_2$)	0.032* (0.016)	0.069** (0.019)	0.050** (0.009)	0.036** (0.013)	0.019 (0.010)	-0.057** (0.016)	-0.013 (0.009)	-0.012 (0.009)
Dummy (α_3)	0.054** (0.010)	0.003 (0.018)	0.026* (0.013)	0.036* (0.012)	not reported			
Intercept (α_0)	0.092** (0.007)	0.028 (0.017)	0.055** (0.010)	0.058 (0.008)	not reported			
R^2	0.265 (0.028)	0.562 (0.043)	0.546 (0.042)	0.519 (0.037)	0.215 (0.025)	0.436 (0.046)	0.405 (0.046)	0.384 (0.036)

Panel B	Firm size interaction model				Erickson and Whited (2000), Table 8			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q* (β)	0.016** (0.002)	0.042** (0.004)	0.036** (0.003)	0.038** (0.002)	0.014** (0.002)	0.046** (0.007)	0.057** (0.005)	0.041** (0.004)
	Less constrained firms							
CF/K (α_1)	0.083** (0.020)	-0.027 (0.035)	0.008 (0.025)	0.007 (0.027)	0.226** (0.059)	-0.125 (0.089)	-0.190 (0.093)	-0.012 (0.074)
	More constrained firms							
CF/K ($\alpha_1+\alpha_2$)	0.063** (0.017)	0.040 (0.030)	0.027 (0.024)	0.030 (0.023)	0.043 (0.023)	-0.062 (0.051)	-0.061 (0.049)	-0.002 (0.046)
Dummy (α_3)	0.029 (0.015)	-0.038 (0.026)	-0.014 (0.019)	-0.015 (0.019)	not reported			
Intercept (α_0)	0.123** (0.008)	0.045** (0.015)	0.068** (0.014)	0.064** (0.010)	not reported			
R^2	0.267 (0.028)	0.546 (0.048)	0.541 (0.045)	0.516 (0.038)	0.210 (0.029)	0.433 (0.055)	0.451 (0.055)	0.399 (0.038)

The table presents OLS and GMM minimum-distance estimates. The dependent variable is investment (*I/K*) and the explanatory variables are Tobin's average *Q*, two cash flow-to-capital (*CF/K*) interaction terms, associated with the two groups of firms based on their financing status, a dummy variable equal to one if a firm is financially constrained and equal to zero otherwise, as well as a constant. Firms in the lower one third of each year's distribution of total assets and each year's distribution of capital stock are considered more constrained, while all other firms are considered less-constrained. Heteroscedasticity-robust standard errors are in parenthesis. **, and * indicate significance at the one, and five percent levels.

The coefficients on Tobin's *Q* are positive and significant at the one percent level in both models under all four estimators. As reported by Erickson and Whited (2000) the estimates of the coefficients on Tobin's *Q* and the goodness of fit measures increase under the measurement error-consistent GMM estimators compared to their OLS counterparts. Erickson and Whited (2000) explain this change in magnitude with the ability of the GMM estimators to correct for measurement error in *q*. The coefficients on the cash flow interaction terms however, are not significantly different from zero under any of the measurement error-consistent estimators in panel B. This result is the central finding in Erickson and Whited (2000) and it is interpreted as support for the neoclassical model of investment. In contrast, under OLS which produces inconsistent estimates in the presence of measurement error, the coefficients on the cash flow interaction terms are positive and significant, as they have been reported in many empirical studies not explicitly controlling for measurement errors in *q*. Interestingly, as also reported by Erickson and Whited (2000), the inconsistent OLS estimates of the coefficients on the cash flow terms suggest larger sensitivity of investment to internal funds for the *less-constrained* group of firms. This result has been previously reported by Kaplan and Zingales (1997) and Cleary (1999) and it is in contrast to the findings in Fazarri, Hubbard, and Petersen (1988), who report that firms identified to be financially *more-constrained* exhibit larger sensitivity of investment to cash flow. Erickson and Whited (2000) attribute the conflicting results, reported in studies that do not explicitly control for measurement error in Tobin's *q*, to the inconsistency of the OLS estimates in the presence of measurement error. In fact, Tobin's marginal *q* is not directly observable and measurement error is likely to be present in investment-Tobin's *q* regressions. Therefore, we will report the OLS estimates only for the purpose of comparison with previous studies that use the same method of estimation. As noted above, we consider GMM estimators utilizing up to third- (GMM3), up to fourth- (GMM4), and up to fifth-order moments (GMM5). Whited and Bakke (2010) perform Monte Carlo simulations studying the properties of these measurement error-consistent estimators and show that the fourth-order GMM estimator (GMM4) provides the best estimates of all parameters in terms of bias, mean absolute deviation, and probability that the estimate is within a close interval of its true value. In our subsequent tests, we will focus our inference on the measurement error-consistent GMM4 estimates and will report GMM3 and GMM5 estimates to demonstrate the robustness of our results.

In Table 3 we consider split-sample estimation and relax the assumption that β is the same for *more-constrained* and *less-constrained* firms. We estimate the specification outlined in equation (2) above separately on the group of *more-constrained* and the group of less-constrained firms using firm size to proxy for financing status. Panel A considers the same sample period as in Table 2 (1992 to 1995). Out of the 3,888 observations in the balanced panel, for that period, 1,020 are identified as *more-constrained* and the remaining 2,868 are identified as *less-constrained*. The coefficients on Tobin's *Q* are positive and significant at the one percent level for both groups of firms under all four estimators. The OLS estimates of the coefficients on cash flow are positive and significant for both groups of firms. In contrast to the results in Table 2, the GMM4 estimate in the group of *more-constrained* firms indicates significant positive sensitivity of investment to cash flow. The GMM3 and GMM5 estimates for the *more-constrained* group and all three GMM estimates for the *less-constrained* group remain not significantly different from zero. Allowing for a group-specific coefficient on Tobin's *Q* increases the GMM4 cash flow sensitivity estimate for the *more-constrained* group (from not significantly different from zero to 0.041) and decreases its standard error (from 0.024 to 0.020). The significant positive estimate, resulting from the GMM4 estimator, found to be performing the best out of the three measurement error-consistent estimators, casts doubt on the robustness of the findings in Erickson and Whited (2000) for the group of *more-constrained* firms. In panels B and C, of Table 3, we present results from minimum distance estimations of the same specification in the two consecutive four-year balanced panels - 1996 to 1999 and 2000 to 2003. We need to verify whether the significant sensitivity of investment to cash flow is a result isolated to the GMM4 estimator for the 1992-1995 period. The coefficients on Tobin's *Q* are positive and significant at the one percent level for both groups of firms under all four estimators in panels B and C.

TABLE 3
SPLIT-SAMPLE REGRESSION RESULTS - BALANCED PANELS

	Financing status							
Panel A	More constrained (1,020 obs.)				Less constrained (2,868 obs.)			
1992-1995	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.015** (0.002)	0.046** (0.008)	0.019** (0.002)	0.042** (0.004)	0.017** (0.002)	0.039** (0.004)	0.037** (0.004)	0.039** (0.003)
CF/K	0.059** (0.018)	0.045 (0.031)	0.041* (0.020)	-0.004 (0.034)	0.088** (0.020)	-4.0E-4 (0.030)	0.006 (0.029)	-0.013 (0.028)
Intercept	0.138** (0.012)	-0.039 (0.054)	0.128** (0.017)	-0.003 (0.029)	0.130** (0.008)	0.059** (0.014)	0.071** (0.015)	0.058** (0.012)
R^2	0.190 (0.031)	0.625 (0.053)	0.515 (0.042)	0.678 (0.053)	0.323 (0.039)	0.496 (0.066)	0.472 (0.053)	0.592 (0.044)
Panel B	More constrained (1,040 obs.)				Less constrained (3,112 obs.)			
1996-1999	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.015** (0.002)	0.033** (0.005)	0.023** (0.002)	0.037** (0.003)	0.015** (0.001)	0.031** (0.002)	0.024** (0.002)	0.032** (0.001)
CF/K	0.054** (0.011)	0.039** (0.016)	0.051** (0.015)	0.071** (0.021)	0.009 (0.003)	3.0E-4 (0.002)	0.001 (0.003)	-0.003 (0.003)
Intercept	0.173** (0.013)	0.030 (0.046)	0.093** (0.022)	-0.011 (0.031)	0.155** (0.006)	0.093** (0.011)	0.114** (0.009)	0.131** (0.007)
R^2	0.184 (0.026)	0.606 (0.057)	0.492 (0.041)	0.641 (0.050)	0.317 (0.031)	0.521 (0.044)	0.415 (0.032)	0.440 (0.032)
Panel C	More constrained (932 obs.)				Less constrained (2,588 obs.)			
2000-2003	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.013** (0.002)	0.032** (0.003)	0.025** (0.003)	0.033** (0.004)	0.014** (0.001)	0.023** (0.002)	0.023** (0.001)	0.024** (0.001)
CF/K	0.049** (0.008)	0.039** (0.014)	0.041** (0.014)	0.044** (0.016)	0.008 (0.008)	-0.034** (0.008)	-0.025* (0.010)	-0.030** (0.009)
Intercept	0.109** (0.010)	0.034 (0.024)	0.061* (0.025)	-0.019 (0.028)	0.115** (0.006)	0.067** (0.016)	0.057** (0.010)	0.058** (0.009)
R^2	0.315 (0.048)	0.745 (0.057)	0.514 (0.054)	0.490 (0.053)	0.364 (0.040)	0.692 (0.044)	0.649 (0.036)	0.698 (0.030)

The table presents OLS and GMM minimum-distance estimates. The dependent variable is investment (*I/K*) and the explanatory variables are Tobin's average *Q*, a cash flow-to-capital (*CF/K*) term, as well as a constant. Firms in the lower one third of each year's distribution of total assets and each year's distribution of capital stock are considered more constrained, while all other firms are considered less-constrained. Heteroscedasticity-robust standard errors are in parenthesis. **, and * indicate significance at the one, and five percent levels.

Focusing on the sensitivities of investment to cash flow both panels indicate that the group of *more-constrained* firms exhibits positive sensitivities all of which are significant at the one percent level. The result obtains not only with OLS, but also with all three measurement error-consistent GMM estimators. This result demonstrates that the sensitivity of investment to cash flow for financially more constrained firms cannot be attributed to measurement error in Tobin's *q*. The investment of firms facing financing constraints is positively associated with the generated cash flow. In contrast, the sensitivities of investment to cash flow for the group of financially *less-constrained* firms, estimated with GMM, are smaller in magnitude, than the corresponding sensitivities for the group of *more-constrained* firms, and remain insignificant in panels A and B. In panel C, considering the period between 2000 and 2003, the estimated cash flow sensitivities for the firms identified as *less-constrained* fall below zero. Negative sensitivities of investment to cash flow have been reported before in the investments literature for specific groups of firms. One of the suggested explanations for this result is that some firms continue spending on capital goods despite a decrease in cash flow for that period. Our measurement error-consistent estimates from Table 3 support the Fazarri, Hubbard, and Petersen (1988) hypothesis that investment of financially more-constrained firms is positively associated with cash flow.

Next, we relax the requirement for a balanced panel, allowing firms with less than full record of data to enter the sample, and consider the entire sample period - from 1990 to 2004. With an unbalanced panel we use the approach established by Fama-MacBeth (1973) to summarize the cross sectional estimates. The approach has been applied to investment-Tobin's *Q* specifications using measurement error-consistent estimation in Whited and Bakke (2010). Table 4 presents results from split-sample estimations using firm size to proxy for financing constraints.

TABLE 4
SPLIT-SAMPLE REGRESSION RESULTS - UNBALANCED PANEL, 1990-2004

	Financing status							
	More constrained (6,115 obs.)				Less constrained (16,080 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.019**	0.090**	0.049**	0.041**	0.018**	0.046**	0.030**	0.030**
	(0.001)	(0.026)	(0.010)	(0.005)	(0.001)	(0.004)	(0.002)	(0.003)
CF/K	0.032*	0.069**	0.050**	0.036**	0.019	-0.057**	-0.013	-0.012
	(0.016)	(0.019)	(0.009)	(0.013)	(0.010)	(0.016)	(0.009)	(0.009)
Intercept	0.154**	-0.531	-0.120	-0.029	0.139**	-0.006	0.079**	0.085**
	(0.007)	(0.274)	(0.084)	(0.030)	(0.006)	(0.021)	(0.010)	(0.011)
R^2	0.210	0.697	0.551	0.549	0.313	0.681	0.543	0.513
	(0.021)	(0.085)	(0.044)	(0.046)	(0.013)	(0.038)	(0.027)	(0.024)

The table presents OLS and GMM estimates summarized using the procedure in Fama and MacBeth (1973). The dependent variable is investment (*I/K*) and the explanatory variables are Tobin's average *Q*, a cash flow-to-capital (*CF/K*) term, as well as a constant. Firms in the lower one third of each year's distribution of total assets and each year's distribution of capital stock are considered more constrained, while all other firms are considered less-constrained. Fama-MacBeth standard errors are in parenthesis. **, and * indicate significance at the one, and five percent levels.

The coefficients on Tobin's *Q* are positive and significant at the one percent level for both groups of firms under all four estimators. The measurement error-consistent GMM estimates of Tobin's *Q* coefficients and the goodness of fit measure are larger than their corresponding OLS estimates as it was reported in Erickson and Whited (2000). Turning to the sensitivities of investment to cash flow our results from Table 3 are confirmed in an unbalanced panel for the entire sample period. All three measurement error-consistent GMM estimates of the coefficients on cash flow for the group of *more-constrained* firms are positive and significant at the one percent level. In contrast, two of the GMM estimates for the less-constrained group of firms are not significantly different from zero, while the GMM3 estimate is negative. The results in Table 4 confirm and extend the results from Table 3 to a larger sample, after relaxing the requirement for a balanced panel, and considering the entire sample period.

Using a more parsimonious specification, as in Tables 3 and 4, that allows for firms of different financing status to have different sensitivity of investment to Tobin's *Q*, reveals that financially constrained firms exhibit investment that is positively associated with cash flow, even after we take into account possible measurement error in *q*. Next, we turn to explore the robustness of our results.

Robustness of Results

Our next step is to test the robustness of the results established in Tables 3 and 4. First, to alleviate any concerns that firm size might not be capturing well the financing status of a firm, we consider two alternative proxies for financing constraints - Cleary's (1999) Z_{FC} index and Whited and Wu's (2006) *WW* index. In Table 5 we report results from split-sample estimations based on unbalanced panels over the entire sample period. The results in panel A are based on using the Z_{FC} index to proxy for financing constraints. Low Z_{FC} index values indicate larger probability that the firm is financially constrained. Each year firms are ranked according to their beginning-of-the-period index values and firms in the lower one half of the distribution are considered *more-constrained*, while firms in the higher one half of the distribution are considered *less-constrained*.[5] In panel B we report results based on using the *WW* index to proxy for financing constraints. High index values indicate larger probability that the firm is financially constrained. Each year firms are ranked according to their index values and the firms in the higher one half of the distribution are considered *more-constrained*, while firms in the lower one half of the distribution are considered *less-constrained*.

Tobin's *Q* coefficient estimates are positive and significant at the one percent level for both groups of firms, regardless of the proxy for financing constraints. The measurement error-consistent GMM estimates of the coefficients on cash flow are positive and significant at the one percent level for the group of *more-constrained* firms, while their counterparts for the group of *less-constrained* firms remain not significantly different from zero in both panels. This result confirms our findings reported in Tables 3 and 4 that financially *more-constrained* firms exhibit investment sensitive to cash flow after accounting for measurement error in Tobin's *q*. In contrast, financially *less-constrained* firms exhibit no sensitivity of investment to cash flow.

Interestingly, the OLS estimates of the cash flow sensitivities in panel A indicate a positive and significant sensitivity for the *less-constrained* firms and an insignificant sensitivity for the *more-constrained* firms, which is consistent with the finding in Cleary (1999) that *less-constrained* firms have larger sensitivities than *more-constrained* firms. Erickson and Whited (2000) illustrate how measurement error in Tobin's *q* can produce OLS results of this nature.

Next, we turn to using the presence of credit rating as a proxy for financing constraints. As we noted above, the presence of credit rating is likely to be a good indicator for financially less-constrained firms, but we do not expect it to be able to reliably identify financially more-constrained firms. Tables 6 and 7 report split-sample results based on the presence of credit rating as a proxy for financing constraints. Out of the 22,195 firm-year observations in our sample, 6,190 have a credit rating reported in COMPUSTAT and are considered l*ess-constrained* in the estimations presented in Table 6, while the remaining 16,005 firm-year observations do not have any credit rating reported and are considered *more-constrained*. In Table 6 the coefficients on Tobin's *Q* are positive and significant at the one percent level for both groups of firms under all four estimators. The measurement error-consistent estimates of the coefficient on cash flow for the group of *less-constrained* firms remain not significantly different from zero.

TABLE 5
ROBUSTNESS OF SPLIT-SAMPLE REGRESSION RESULTS USING ALTERNATIVE MEASURES OF FINANCING STATUS, 1990-2004

	Financing status measured using Cleary's (1999) Z_{FC} index							
Panel A	More constrained (9,918 obs.)				Less constrained (9,928 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.019**	0.059**	0.034**	0.039**	0.016**	0.041**	0.034**	0.032**
	(0.001)	(0.008)	(0.005)	(0.005)	(0.001)	(0.007)	(0.005)	(0.003)
CF/K	0.010	0.086**	0.038**	0.046**	0.062**	-0.035	-0.016	-0.015
	(0.007)	(0.021)	(0.013)	(0.013)	(0.011)	(0.031)	(0.016)	(0.014)
Intercept	0.117**	-0.070*	0.047**	0.027	0.163**	0.020	0.073**	0.082**
	(0.008)	(0.031)	(0.016)	(0.016)	(0.007)	(0.032)	(0.017)	(0.014)
R^2	0.163	0.435	0.267	0.239	0.224	0.637	0.541	0.596
	(0.033)	(0.079)	(0.055)	(0.059)	(0.027)	(0.038)	(0.047)	(0.032)
Panel B	**Financing status measured using Whited and Wu's (2006) *WW* index**							
	More constrained (11,020 obs.)				Less constrained (11,025 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.019**	0.070**	0.035**	0.031**	0.016**	0.036**	0.036**	0.036**
	(0.001)	(0.011)	(0.003)	(0.003)	(0.003)	(0.011)	(0.009)	(0.009)
CF/K	0.030**	0.020**	0.027**	0.024**	0.048	-0.039	-0.062	-0.048
	(0.006)	(0.008)	(0.005)	(0.005)	(0.030)	(0.063)	(0.054)	(0.049)
Intercept	0.149**	-0.292**	0.011	0.055**	0.132**	0.063*	0.080**	0.074**
	(0.007)	(0.103)	(0.017)	(0.015)	(0.005)	(0.027)	(0.020)	(0.024)
R^2	0.237	0.750	0.540	0.605	0.336	0.502	0.454	0.516
	(0.015)	(0.040)	(0.020)	(0.075)	(0.031)	(0.061)	(0.048)	(0.043)

The table presents OLS and GMM estimates summarized using the procedure in Fama and MacBeth (1973). The dependent variable is investment (*I/K*) and the explanatory variables are Tobin's average *Q*, a cash flow-to-capital (*CF/K*) term, as well as a constant. In panel A, firms in the lower one half of each year's distribution of Cleary's(1999) financing constraints index are considered *more constrained*, while firms in the higher one half of each year's distribution of the index are considered *less-constrained*. In panel B, firms in the higher one half of each year's distribution of the Whited and Wu's (2006) financing constraints index are considered *more constrained*, while firms in the lower one half of each year's distribution of the index are considered *less-constrained*. Fama-MacBeth standard errors are in parenthesis. **, and * indicate significance at the one, and five percent levels.

The result for the group of *less-constrained* firms re-emphasizes that firms with frictionless access to external financing need not condition their capital spending in a given period on the cash flow they generate that period. However, the corresponding estimates for the *more constrained* group of firms are positive but not significantly different from zero, which is in contrast to our results in Tables 3 to 5. These estimates are smaller in magnitude compared to the estimates for the *more-constrained* group from the previous split-sample estimations. The only difference between our tests reported in Tables 4 and 5, and those reported in Table 6 is the criterion used to identify financially constrained firms. We need to look closer into the absence of credit rating as a proxy for financing constraints to understand the difference in our results for the groups of *more-constrained* firms.

TABLE 6
ROBUSTNESS OF SPLIT-SAMPLE REGRESSION RESULTS USING AVAILABILITY OF CREDIT RATING TO MEASURE FINANCING STATUS, 1990-2004

	Financing status measured using availability of credit rating							
	More constrained (16,005 obs.)				Less constrained (6,190 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.019**	0.067**	0.045**	0.043**	0.016**	0.033**	0.031**	0.034**
	(0.001)	(0.009)	(0.009)	(0.012)	(0.001)	(0.003)	(0.005)	(0.004)
CF/K	0.019	0.002	0.013	0.011	0.060**	-0.002	0.002	-0.011
	(0.010)	(0.010)	(0.009)	(0.009)	(0.019)	(0.016)	(0.019)	(0.020)
Intercept	0.151**	-0.219**	-0.052	-0.027	0.117**	0.044**	0.060**	0.046**
	(0.006)	(0.070)	(0.068)	(0.091)	(0.006)	(0.015)	(0.016)	(0.015)
R^2	0.229	0.696	0.558	0.675	0.423	0.641	0.586	0.605
	(0.014)	(0.042)	(0.031)	(0.112)	(0.029)	(0.039)	(0.043)	(0.040)

The table presents OLS and GMM estimates summarized using the procedure in Fama and MacBeth (1973). The dependent variable is investment (*I/K*) and the explanatory variables are Tobin's average *Q*, a cash flow-to-capital (*CF/K*) term, as well as a constant. Firms with no credit rating are considered *more constrained*, while firms with credit rating are considered *less-constrained*. Fama-MacBeth standard errors are in parenthesis. **, and *indicate significance at the one, and five percent levels.

As we discussed above, the absence of credit rating is a poor indicator for a firm being financially constrained. As a consequence, the group of firms with no credit rating, in Table 6, likely contains both financially more-constrained and less-constrained firms. Since the cash flow sensitivity of investment of less-constrained firms has been found to be close to zero, a natural consequence to combining less-constrained and more-constrained firms in one group is to observe a group estimate that is closer to zero than the one obtained if we were able to isolate only more-constrained firms. We argue that the small magnitude and loss of significance of the cash flow coefficients for the group of firms with no credit rating in Table 6 is a consequence of the poor performance of the absence of credit rating to identify financially more-constrained firms. To illustrate our argument we consider using the presence of credit rating in combination with each one of the other three proxies for financing constraints. The use of another proxy in combination with the presence of credit rating allows us to isolate financially more-constrained firms within the group of firms with no credit rating. Table 7 reports results from split-sample estimations using the presence of credit rating in combination with another proxy for financing constraints to identify financially constrained firms. In panel A, firms are identified as *more-constrained* if both the credit rating and the firm size criteria identify them as more-constrained, e.g. they have no credit rating, they fall in the lower one third of each year's distribution of total assets, and they fall in the lower one third of each year's distribution of capital stock. Similarly, firms are identified as *less-constrained* if both the credit rating and the firm size criteria identify them as less-constrained. The two criteria need to agree on the classification of an observation so that it is included in the *more-constrained* or in the *less-constrained* group. If the credit rating and the firm size criteria disagree on the group, to which a particular observation should belong, such observation is discarded. In panel A of Table 7 the coefficients on Tobin's *Q* are positive and significant at the one percent level for both groups of firms under all four estimators. The measurement error-consistent estimates of the coefficient on cash flow are positive and significant at the one percent level for the group of *more-constrained* firms, while the corresponding estimates for the group of *less-constrained* firms are not significantly different from zero. After removing the misclassified firms - those with no credit rating but identified as less-constrained by the firm size criterion - the group of *more-constrained* firms continues to have positive and highly significant sensitivity of investment to cash flow under all four estimators. This result confirms our previous findings reported in Tables 3 to 5.

TABLE 7
ROBUSTNESS OF SPLIT-SAMPLE REGRESSION RESULTS USING AVAILABILITY OF CREDIT RATING IN COMBINATION WITH FIRM SIZE, Z_{FC} INDEX, OR *WW* INDEX TO MEASURE FINANCING STATUS, 1990-2004

Financing status measured using availability of credit rating and firm size

Panel A	More constrained (6,088 obs.)				Less constrained (6,163 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.019**	0.091**	0.049**	0.041**	0.016**	0.034**	0.033**	0.033**
	(0.001)	(0.026)	(0.010)	(0.005)	(0.002)	(0.003)	(0.005)	(0.004)
CF/K	0.032*	0.069**	0.050**	0.036**	0.059**	-0.007	-0.010	-0.010
	(0.016)	(0.020)	(0.009)	(0.013)	(0.019)	(0.016)	(0.020)	(0.020)
Intercept	0.154**	-0.531	-0.121	-0.030	0.117**	0.044**	0.055**	0.054**
	(0.007)	(0.274)	(0.084)	(0.030)	(0.006)	(0.015)	(0.015)	(0.014)
R^2	0.210	0.698	0.553	0.552	0.424	0.641	0.598	0.608
	(0.021)	(0.085)	(0.044)	(0.046)	(0.029)	(0.040)	(0.041)	(0.040)

Financing status measured using availability of credit rating and Cleary's (1999) index

	More constrained (7,098 obs.)				Less constrained (3,076 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.019**	0.061**	0.035**	0.041**	0.011**	0.029**	0.028**	0.031**
	(0.001)	(0.009)	(0.005)	(0.007)	(0.002)	(0.005)	(0.004)	(0.006)
CF/K	0.009	0.100**	0.047**	0.053**	0.106**	-0.010	-0.004	-0.011
	(0.006)	(0.021)	(0.016)	(0.016)	(0.027)	(0.027)	(0.021)	(0.034)
Intercept	0.120	-0.087*	0.042*	0.020	0.129**	0.077**	0.077**	0.056
	(0.008)	(0.036)	(0.018)	(0.021)	(0.008)	(0.014)	(0.012)	(0.031)
R^2	0.232	0.655	0.487	0.476	0.434	0.547	0.565	0.364
	(0.013)	(0.050)	(0.043)	(0.040)	(0.035)	(0.044)	(0.040)	(0.185)

TABLE 7 (CONTINUED)
ROBUSTNESS OF SPLIT-SAMPLE REGRESSION RESULTS USING AVAILABILITY OF CREDIT RATING IN COMBINATION WITH FIRM SIZE, Z_{FC} INDEX, OR *WW* INDEX TO MEASURE FINANCING STATUS, 1990-2004

Financing status measured using availability of credit rating and Whited and Wu's (2006) index

Panel C	More constrained (10,257 obs.)				Less constrained (5,390 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's *Q*	0.019**	0.071**	0.035**	0.035**	0.012**	0.023**	0.023**	0.024**
	(0.001)	(0.011)	(0.003)	(0.004)	(0.003)	(0.006)	(0.007)	(0.006)
CF/K	0.030**	0.022*	0.029**	0.026**	0.115**	0.051	0.050	0.046
	(0.006)	(0.009)	(0.006)	(0.006)	(0.034)	(0.049)	(0.054)	(0.047)
Intercept	0.149**	-0.293**	0.013	0.031	0.113**	0.080**	0.081**	0.078**
	(0.007)	(0.105)	(0.018)	(0.019)	(0.006)	(0.012)	(0.012)	(0.011)
R^2	0.234	0.736	0.531	0.601	0.458	0.570	0.585	0.567
	(0.015)	(0.041)	(0.021)	(0.081)	(0.037)	(0.040)	(0.037)	(0.039)

The table presents OLS and GMM estimates summarized using the procedure in Fama and MacBeth (1973). The dependent variable is investment (*I/K*) and the explanatory variables are Tobin's average *Q*, a cash flow-to-capital (*CF/K*) term, as well as a constant. In panel A, firms with no credit rating, in the lower one third of each year's distribution of total assets, and each year's distribution of capital stock are considered *more constrained*, while all other firms with credit rating are considered *less-constrained*. In panel B, firms with no credit rating and in the lower one half of each year's distribution of Cleary's (1999) financing constraints index are considered *more constrained*, while firms with credit rating and in the higher one half of each year's distribution of the index are considered *less-constrained*. In panel C, firms with no credit rating and in the higher one half of each year's distribution of Whited and Wu's (2006) financing constraints index are considered *more constrained*, while firms with credit rating and in the lower one half of each year's distribution of the index are considered *less-constrained*. Fama-MacBeth standard errors are in parenthesis.**, and * indicate significance at the one, and five percent levels.

Panels B and C of Table 7 demonstrate that the investment of *more-constrained* firms is sensitive to cash flow not only when we use firm size, but also when we use the Z_{FC} index or the *WW* index as a criterion serving to separate more-constrained from less-constrained observations within those with no credit rating. In panel B firms are identified as *more-constrained* if both the credit rating and the Z_{FC} index criteria identify them as more-constrained, e.g. they have no credit rating and they fall in the lower one half of each year's distribution of the Z_{FC} index. Similarly, firms are identified as *less-constrained* if both the credit rating and the Z_{FC} index criteria identify them as *less-constrained*. The separation into a group of *more-constrained* and a group of *less-constrained* firms in panel C is based on the credit rating and the *WW* index criteria. If a firm-year observation is identified as *more-constrained* by both the credit rating and the *WW* index criteria, e.g. the firm has no reported credit rating and the observation falls in the higher one half of the distribution of the *WW* index, then it is included in the *more-constrained* group. Similarly, if a firm-year observation is identified as *less-constrained* by both the credit rating and the *WW* index criteria, then it is included in the *less-constrained* group. In both panels, B and C, the coefficients on Tobin's *Q* are positive and significant at the one percent level for both groups of firms under all four estimators. In addition, the measurement error-consistent estimates of the coefficient on cash flow are positive and highly significant for the group of *more-constrained* firms, while the corresponding estimates for the group of *less-constrained* firms are not significantly different from zero. The results in Table 7 demonstrate that firms with no credit rating that are identified as *more-constrained* by any of the other three criteria have investment that is sensitive to cash flow even after we control for measurement error in Tobin's q and regardless of the estimator.

To explore further the robustness of our results we consider an alternative way of constructing the regression variables. Table 8 presents results from split-sample estimations using variables constructed as in Whited and Bakke (2010) and firm size to identify more-constrained firms. The coefficients on Tobin's Q are positive and significant at the one percent level for both groups of firms under all four estimators.

TABLE 8
ROBUSTNESS OF SPLIT-SAMPLE REGRESSION RESULTS USING ALTERNATIVE CONSTRUCTION OF REGRESSION VARIABLES - UNBALANCED PANEL, 1990-2004

	Financing status							
Panel A	More constrained (6,111 obs.)				Less constrained (16,072 obs.)			
	OLS	GMM3	GMM4	GMM5	OLS	GMM3	GMM4	GMM5
Tobin's Q	0.021**	0.064**	0.036**	0.043**	0.017**	0.044**	0.029**	0.045**
	(0.003)	(0.011)	(0.005)	(0.004)	(0.002)	(0.007)	(0.004)	(0.014)
CF/K	0.033*	0.077**	0.051**	0.066**	0.007	-0.074**	-0.022	-0.052**
	(0.013)	(0.013)	(0.010)	(0.010)	(0.010)	(0.027)	(0.013)	(0.019)
Intercept	0.075**	-0.137*	0.010	-0.017	0.081**	0.010	0.048**	0.018
	(0.008)	(0.065)	(0.020)	(0.015)	(0.004)	(0.013)	(0.008)	(0.027)
R^2	0.235	0.563	0.553	0.589	0.288	0.595	0.487	0.540
	(0.036)	(0.068)	(0.065)	(0.059)	(0.038)	(0.042)	(0.048)	(0.061)

The table presents OLS and GMM estimates summarized using the procedure in Fama and MacBeth (1973).The dependent variable is investment (*I/K*) and the explanatory variables are Tobin's average Q, a cash flow-to-capital (*CF/K*) term, as well as a constant. Regression variables are constructed as in Whited and Bakke (2010).Firms in the lower one third of each year's distribution of total assets and each year's distribution of capital stock are considered *more constrained*, while all other firms are considered *less-constrained.* Fama-MacBeth standard errors are in parenthesis. **, and * indicate significance at the one, and five percent levels.

The measurement error-consistent estimates of the cash flow sensitivities of the *more-constrained* group are positive and significant at the one percent level. The GMM4 estimate of the cash flow coefficient for the less-constrained group is not significantly different from zero, while the GMM3 and GMM5 coefficients are significantly negative. The results in Table 8 support our findings above confirming that the investment of financially constrained firms is sensitive to cash flow after controlling for measurement error in Tobin's q under alternative construction of the regression variables.

CONCLUDING REMARKS

Tobin's q is not a sufficient statistic for investment when firms are financially constrained. Financing constraints explain investment and manifest themselves in investment-cash flow sensitivity results, even after controlling for errors in measuring Tobin's q. Our results depart from those of Erickson and Whited (2000) because we adopt a more parsimonious specification allowing for firms with differential financing status to have different sensitivity of investment to Tobin's Q.

The effect of cash flow on investment is positive for financially constrained firms, while it remains negligible for financially less-constrained firms. The positive investment-cash flow sensitivity for financially constrained firms is confirmed under various proxies for financing constraints and cannot be attributed to measurement error in Tobin's *q*. These investment-cash flow sensitivity results relate well to the larger macroeconomic context where the effects of financing frictions on investment are robustly documented.

ENDNOTES

1. Please see Hubbard (1998) for an extensive review of the investments literature.
2. Papers providing support to Fazzari, Hubbard, and Petersen (1988) include Allayannis and Mozumdar (2004), Fazzari, Hubbard, and Petersen (2000), Gilchrist and Himmelberg (1995), Hoshi, Kashyap, and Scharfstein (1991), Oliner and Rudebusch (1992), and Schaller (1993). Papers providing support to Kaplan and Zingales (1997) include Cleary (1999), Cleary, Povel, and Raith (2004), Kadapakkam, Kumar, and Riddick (1998), and Kaplan and Zingales (2000).
3. Studies utilizing this approach are Fazzari, Hubbard, and Petersen (1988), Kaplan and Zingales's (1997), Cleary (1999), Allayannis and Mozumdar (2004), and Baker, Stein, and Wurgler (2003) among others.
4. Our sample begins in 1990 since SFAS no. 95 was enacted in 1987, and lagged values for two periods are used to calculate the beginning-of-the-period Z_{FC} index.
5. Using the Z_{FC} index and the *WW* index as proxies for financing constraints we have also considered alternative cut-off points (e.g. top vs. bottom one third or top vs. bottom two quintiles) to define the groups of *more-constrained* and *less-constrained* firms. We obtain qualitatively unchanged results under each of these definitions for each of the indices.

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APPENDIX

A. Variable definitions

Investment $(I_t/K_t)$is measured as Capital Expenditures (COMPUSTAT *capx*) in year *t* over the Replacement Value of Capital Stock in year *t-1*.

Cash flow (CF_t/K_t) is measured as the sum of Income Before Extraordinary Items (*ib*) in year t and Depreciation and Amortization (*dp*) in year *t*, over the Replacement Value of Capital Stock in year *t-1*.

Tobin's average $Q_t$is the market value of capital stock divided by its replacement value:

$$Q_t = \frac{D_t + E_t - INV_t}{K_{t-1}},$$

where the market value of capital stock is the sum of the market value of debt, the market value of common stock, and the market value of preferred stock (for the firms having preferred stock outstanding) minus the replacement value of inventories.

The Market Value of Debt (D_t): To estimate the market value of debt we follow the procedure in Salinger and Summers (1983), and Whited (1992).

The Market Value of Equity (E_t): is the sum of the market value of common stock and the market value of preferred stock. The market value of common stock is calculated as the number of shares outstanding times the close price at the end of the fiscal year (*cshoxprcc_f*) and the market value of preferred stock is the preferred dividend (*dvp*) divided by Moody's medium-grade preferred stock dividend yield. The Moody's medium-grade preferred stock dividend yield is from the Appendix to the 2002 Moody's Industrial Manual. The Industrial Manual discontinues reporting data on the preferred stock dividend yield for years after 2002. We use the book value of preferred stock to approximate its market value for the years after 2002.

The Replacement Value of Inventory (INV_t): To obtain the replacement value of inventory we use the method suggested by Lewellen and Badrinath (1997). The replacement value of inventories for firms using the FIFO method equals the reported book value (*invt*). For firms using the LIFO method we convert the reported book value into its FIFO equivalent by adding the reported LIFO Reserve (*lifr*).

The Replacement Value of Capital Stock (K_t):To obtain the Replacement Value of Capital Stock we use the perpetual inventory method described in Salinger and Summers (1983) and used in Fazarri, Hubbard, and Petersen (1988), and Whited (1992).

Another approach in the measurement of the replacement value of capital stock is suggested in Whited and Bakke (2010), who use the book value of Gross Property, Plant, and Equipment (*ppegt*) to proxy for the replacement value of capital stock. In constructing Tobin's average *Q* they use the book values of debt and inventory to proxy for their market values.

B. Financing Constraints indices

The Cleary's (1999) index (Z_{FC}): Cleary (1999) suggests the use of discriminant analysis to assess the degree of financing constraints faced by a firms. The construction of the index involves estimating a probit model, where the dependent variable is an indicator equal to one if the firm increased its dividends and is equal to zero if the firm decreased its dividends. Cleary's (1999) index is calculated as the fitted values from the estimated specification:

$$\begin{aligned}\hat{Z}_{FC} = & -\underset{(0.007)}{0.017} \times Current + \underset{(0.0004)}{0.0003} \times FCC_{ov} + \underset{(0.002)}{0.0007} \times SLACK/K + \underset{(0.140)}{3.904} \times NI\% \\ & + \underset{(0.041)}{0.467} \times Sales\ Growth - \underset{(0.064)}{0.439} \times Debt + \underset{(0.024)}{0.376}\end{aligned}$$

Standard errors are reported in parenthesis under the estimated coefficients. We follow Cleary (1999) to construct the variables necessary to estimate the model and compute the Z_{FC} index values. Dividends are measured as Dividends per Share (*dvpsx_f*). The current ratio (*Current*) is Current Assets (*act*) over Current Liabilities (*lct*). The fixed charge coverage *(FCCov)* ratio is Operating Income After Depreciation (*oiadp*) over the sum of Interest Expense (*xint*) and Preferred Dividends (*dvp*). Slack *(SLACK/K)* is Cash and Short Term Investments (*che*), plus fifty percent of Inventory (*invt*), plus seventy percent of Accounts Receivable (*rect*), minus Notes Payable (*np*), over Net Property, Plant, and Equipment (ppent). The net income margin *(NI%)*is the Income Before Extraordinary Items (*ib*) over Net Sales (sale). The debt ratio *(Debt)* is the sum of the Debt Due in One Year (*dd1*) and Long-Term Debt (*dltt*), over Total Assets (*at*).
The Whited and Wu's (2006) index *(WW)*: The values for the WW index are obtained from the expression:

$$WW = -0.091CF_{it} - 0.062DIV\ POS_{it} + 0.021TLTD_{it} - 0.044LNTA_{it} + 0.102ISG_{it} - 0.035\ SG_{it}$$

Variables necessary to compute the index are defined as follows. *CF* is the sum of Income Before Extraordinary Items (*ib*) and Depreciation and Amortization (*dp*), *DIV POS* is an indicator variable assuming value of one if the firm pays cash dividends, *TLTD* is the ratio of the long term debt (*dltt*) to total assets (*at*), *LNTA* is the natural logarithm of total assets (*at*), *ISG* is the average three-digit-SIC industry sales growth obtained by averaging the sales growth of all firms in a particular three-digit-SIC category in a particular year, and *SG* is the individual firm sales growth (*sale* at time *t* minus *sale* at time t-1 divided by *sale* at time *t-1*).

C. GMM Identification
The GMM specification is identified when two conditions are satisfied. The first condition requires that the parameter on Tobin's q, β, be different from zero. The second condition requires that residuals obtained from regressing investment *I/K* on the perfectly measured vector **z** be skewed. The identification test is applied to each cross-section of firms. Consequently, the test produces four statistics, one for each cross section, for each of the four-year balanced panels considered in Tables 2 and 3. For the estimations reported in Tables 4 to 8 the test produces fifteen statistics corresponding to the fifteen years of the sample period from 1990 to 2004. In Table A1 we report the *p-values* of the statistics for the measurement error-consistent estimations presented in Tables 2 to 8.
Overall, the models are well identified. Most importantly, the specifications estimated with the *more-constrained* group of firms are well identified. Out of the 132 *p*-values presented for the *more-constrained* group of firms only 2, both of them in Table 8, are larger than 0.1. Specifications estimated with the *less-constrained* group of firms occasionally exhibit *p*-values larger than 0.1 - out of the 132 *p*-values presented for the *less-constrained* group of firms 18 are larger than 0.1. The estimates from these specifications are both qualitatively and quantitatively similar to estimates for the same group obtained from specifications where all *p*-values are less than 0.05 (i.e. those in panels A and B in Table 3), which alleviates any concerns that the model is not well identified.

TABLE A1
***P*-VALUES FROM IDENTIFICATION TESTS OF VARIOUS MODEL SPECIFICATIONS**

The GMM specification is identified when two assumptions are satisfied. The first assumption requires that the parameter on Tobin's q, β, be different from zero. The second assumption requires that residuals obtained from regressing investment I/K on the perfectly measured vector $\boldsymbol{z}$ containing cash-flow-to-capital interaction terms, and dummy controls be skewed. This identification test is applied to each cross-section of firms. The table therefore reports a p-value for each year considered in the specifications presented in Tables 2 to 8.

	Year							
Model	1990	1991	1992	1993	1994	1995	1996	1997
Table 2. Combined-sample regression results								
Firm size			0.002	<0.001	<0.001	<0.001		
Credit rating			<0.001	<0.001	<0.001	<0.001		
Table 3. Split-sample regression results – balanced panels								
More constrained			0.008	0.032	0.033	0.010	0.001	0.004
Less constrained			0.049	<0.001	<0.001	<0.001	<0.001	<0.001
Table 4. Split-sample regression results – unbalanced panels, 1990-2004								
More constrained	0.004	0.006	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Less constrained	0.158	0.033	0.001	<0.001	0.001	<0.001	<0.001	<0.001
Table 5. Robustness of split-sample regression results using alternative measures of financing status, 1990-2004								
More constrained – panel A	0.003	0.010	0.002	0.021	<0.001	<0.001	0.002	0.001
Less constrained – panel A	0.263	0.002	<0.001	0.001	<0.001	0.001	<0.001	<0.001
More constrained – panel B	<0.001	0.051	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained – panel B	0.335	0.032	0.077	0.001	0.292	0.172	<0.001	0.099
Table 6. Robustness of split-sample regression results using availability of credit rating to measure financing status, 1990-2004								
More constrained	0.001	0.046	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained	<0.001	0.162	0.004	0.006	0.056	0.009	0.006	0.002
Table 7. Robustness of split-sample regression results using alternative measures of financing status								
More constrained – panel A	0.004	0.006	<0.001	0.002	<0.001	<0.001	0.001	<0.001
Less constrained – panel A	<0.001	0.163	0.004	0.006	0.057	0.010	0.009	0.002
More constrained – panel B	<0.001	0.051	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained – panel B	0.335	0.032	0.077	0.001	0.292	0.172	<0.001	0.099
More constrained – panel C	<0.001	0.051	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained – panel C	0.335	0.032	0.077	0.001	0.292	0.172	<0.001	0.099
Table 8. Robustness of split-sample regression results using alternative construction of regression variables, 1990-2004								
More constrained	0.043	0.051	0.001	0.021	<0.001	0.121	<0.001	<0.001
Less constrained	0.271	0.024	0.159	0.023	0.023	<0.001	0.001	<0.001

TABLE A1
***P*-VALUES FROM IDENTIFICATION TESTS OF VARIOUS MODEL SPECIFICATIONS (CONTINUED)**

	Year						
Model	1998	1999	2000	2001	2002	2003	2004
Table 3. Split-sample regression results – balanced panels							
More constrained	0.018	0.001	0.006	0.008	0.029	0.003	
Less constrained	<0.001	0.002	0.706	<0.001	0.001	0.123	
Table 4. Split-sample regression results – unbalanced panels, 1990-2004							
More constrained	<0.001	<0.001	0.006	<0.001	0.001	<0.001	0.003
Less constrained	<0.001	0.102	<0.001	<0.001	<0.001	0.116	<0.001
Table 5. Robustness of split-sample regression results using alternative measures of financing status, 1990-2004							
More constrained – panel A	<0.001	0.001	0.003	0.007	<0.001	0.001	<0.001
Less constrained – panel A	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.072
More constrained – panel B	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained – panel B	0.011	0.029	0.020	<0.001	<0.001	0.090	0.009
Table 6. Robustness of split-sample regression results using availability of credit rating to measure financing status, 1990-2004							
More constrained	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained	0.002	0.037	0.051	<0.001	<0.001	0.001	<0.001
Table 7. Robustness of split-sample regression results using alternative measures of financing status							
More constrained – panel A	<0.001	<0.001	0.006	<0.001	0.001	<0.001	0.004
Less constrained – panel A	<0.001	0.083	0.097	<0.001	<0.001	0.001	<0.001
More constrained – panel B	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained – panel B	0.011	0.029	0.020	<0.001	<0.001	0.090	0.009
More constrained – panel C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Less constrained – panel C	0.011	0.029	0.020	<0.001	<0.001	0.090	0.009
Table 8. Robustness of split-sample regression results using alternative construction of regression variables, 1990-2004							
More constrained	0.013	0.004	0.012	0.008	0.023	<0.001	0.304
Less constrained	<0.001	0.065	<0.001	<0.001	0.015	0.022	<0.001