Q, Cash Flow and Investment: An Econometric Critique*

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Abstract

The effects of measurement and specification error on estimates of the Q and cash flow model of investment are investigated. Two sources of error are considered: expensing of R&D expenditures and failing to identify that component of cash flow which relaxes financing constraints. We apply random-effects and instrumental variables estimators to a model that addresses these sources of error. We find that: (1) the capitalization of R&D strengthens the explanatory power of the model; (2) expected and unexpected components of cash flow have different effects; and (3) the effects of Q are much more evident in firms facing low costs of external finance.

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1. Introduction

The Q model of investment, for all of its analytical appeal, has achieved only modest success in empirical research. Tobin's Q, defined as the ratio of the market value of the firm to the replacement cost (or current cost) value of its assets, can be shown to be a "sufficient statistic" for investment (Chirinko 1995). Yet, beginning with the work of Fazzari, Hubbard and Petersen (1988), and continuing through a growing and now international body of empirical research (UK: Devereux and Schiantarelli (1990), Japan: Hoshi, Kashyap and Scharfstein (1991), Germany: Elston (1993), and Canada: Schaller (1993)), Q has made only a small contribution to the explanatory power of investment spending equations that also include cash flow or some other output-related variable.

The dogged search for the role played by Q in investment decisions is understandable. The Q model of investment, in addition to being soundly grounded in theory, identifies an explicit linkage between the real and financial sectors of the economy. Furthermore, certain empirical regularities appear to be consistent with the Q model: its performance appears to be stronger in subsamples consisting of firms that can be presumed not subject to liquidity constraints than it does in subsamples of apparently liquidity-constrained firms. This interplay of Q and investment with capital market imperfections is itself intriguing, and has led to a sizable literature (for a recent summary, see Schiantarelli, 1995, pp.180-185).

Appearances, however, can be deceiving. Many prior investigators added cash flow variables or other measures of liquidity to the regression equation implied by the Q model in an ad hoc manner. In contrast, Chirinko (1995) derived the Q-and-cash flow model from first principles, and determined that if the additional costs faced by liquidity-constrained firms take the form of a higher cost of capital on funds raised, then Q already incorporates the effects of capital market imperfection–it is a "sufficient statistic for investment" (p. 14), and cash flow need not be added to the model. However, he shows that if the additional cost faced by liquidity-constrained firms is in the form of a higher upfront fee or flotation cost–a "fixed cost" component–then Q is no longer a sufficient statistic, and a measure of liquidity (such as cash flow) is required to properly specify the investment model. Furthermore, a testable implication of this analytical specification is that a fundamental parameter of the model would be larger for firms facing more severe financing constraints. Chirinko found that this relationship was typically contradicted in published research for a number of countries and sample periods.

In this paper, we conduct an econometric investigation of the Q and cash flow model on firm-level panel data, focusing on the sensitivity of the model to measurement and specification errors. We consider two aspects of potential error: first, that intangible expenses (such as research and development) should be capitalized, as their contribution to the value of the firm is impounded in the firm's stockmarket valuation, rather than expensed; and second, that it may be inappropriate to treat anticipated and unanticipated cash flow as equally effective in relaxing the liquidity constraints facing a firm. We partition the sample to account for differential costs of external finance, and find that the model's ability to explain investment spending differs substantially between these subsamples.

The plan of the paper is as follows. In the next section, we briefly survey the performance of the Q model of investment, and consider how econometric issues may explain the model's apparent weaknesses. In Section 3, we describe the data set which we employ in empirical analysis. Section 4 contains our empirical findings, and Section 5 contains our conclusions and suggestions for further research.

2. Measurement and Specification Errors in Q Models

2.1. Measurement Error of Q and the Investment Rate

Many authors (as summarized in Chirinko, 1993) have noted that the Q model has performed poorly in explaining macroeconomic investment. Problems include implausible parameter estimates as well as low explanatory power relative to more traditional, accelerator-type models. Aggregation problems can certainly be at work (Abel and Blanchard 1986); so can measurement problems. Micro-level data can address both sources of error; with respect to measurement error, they may be used to increase the ratio of signal-to-noise in the data. However, Q research has been found to be quite sensitive to measurement problems (Blundell et al., (1992), Perfect and Wiles (1994)). Perfect et al. (1995), for example, obtained very different results when they used a single year's estimate of Q than when they used the average of three years' estimates. Klock, Thies and Baum (1991) show that the standard imputation approach to firm-level Q measurement leads to serious discrepancies relative to direct observation of the replacement cost value of assets and the traded or fair value of debt. They found that not only is Q measured with error, but that the measurement errors are likely to be correlated with financial ratios frequently employed in research.

Consider the following regression:

$$\left(\frac{I}{K}\right) = a + b\,(Q-1) + c\left(\frac{F^*}{K}\right) + \epsilon \tag{2.1}$$

where $\frac{I}{K}$ is gross investment scaled by the capital stock, Q is Tobin's Q, and

$\frac{F^*}{K}$ is that part of cash flow which serves to relax liquidity constraints, scaled by the capital stock. As derived by Chirinko (1995, p.17),

$$a = \frac{\delta\beta}{\beta+\gamma}, b = \frac{1}{\beta+\gamma}, c = \frac{\gamma}{\beta+\gamma} \tag{2.2}$$

where δ is the depreciation rate, β is a parameter defining the rate at which the cost of adjusting the capital stock rises, and γ is a parameter defining the rate at which the flotation costs rise with the level of funds raised. Flotation costs are assumed to be additively separable from adjustment costs and other costs of production. A point estimate of γ may be recovered from a ratio of the estimated coefficients (c/b).

To the extent Q is measured with error–arising, for instance, from researchers' inability to capture all aspects of the firm's valuation by the financial markets in the numerator, and/or the appropriate replacement cost of its assets in the denominator–its coefficient would be biased toward zero, and estimates of other coefficients in the equation would be biased and inconsistent. If Q is the only mismeasured explanatory variable, the attenuation of its coefficient value would be in line with the common empirical result that the effect of Q on investment is implausibly small.[1] This measurement problem can be addressed satisfactorily via instrumental variables estimators if appropriate instruments can be identified.

However, the textbook presentation of "errors-in-variables" considers errors of measurement which are uncorrelated with the true explanatory variables and with the equation's disturbance process. In the Q model, it is very likely that an error of measurement for Q will be correlated with the included cash flow variable. Given that Q can be interpreted as the present value of future cash

[1] However, Chirinko (1993) does not find that measurement problems per se explain the poor performance of the Q model of investment. As shown in Klock et al. (1991), that finding may be largely the result of Chirinko's use of aggregate data (rather than firm-level panel data).

flow, a high correlation can be expected between the mismeasurement of Q and current or lagged cash flow variables.

A particularly significant source of mismeasurement concerns off-balance sheet assets, or intangible assets such as the value of a firm's technology as developed by its expenditures on research and development. While accountants will recognize a value for patents and other intangible assets purchased through arms-length transactions, they will not recognize a value for internally-produced intangibles. Yet, non-defense expenditures on research and development are large, amounting to 1.9 percent of GDP in the United States in 1990, 3.0 percent in Japan and 2.7 percent in Germany (Statistical Abstract of the United States, 1993, p.598). In certain industries, these expenditures exceed investment in plant and equipment. The value of intangible assets has been found to be incorporated into the market's valuation of firms (Hall 1992). Chirinko (1993) and Klock, Baum and Thies (1996) find that recognizing research and development substantially improves performance of the Q model of investment. This recognition involves redefinition of investment spending and the capital stock to incorporate spending on intangibles and the "stock" of intangibles, respectively.

2.2. Specification of the Cash Flow Measure

A specification issue with the Q-and-cash-flow model arises in identifying that part of cash flow that serves to relax a firm's liquidity constraints. This has been addressed in the line of research initiated by Fazzari et al. (1988) by partitioning samples into two or more subsamples, including those considered to be (more) liquidity-constrained and those considered to be non- (or less) liquidity-constrained. Criteria employed have included dividend payout rates, size as measured by sales or by total assets, and association with business groups and/or banks (Schiantarelli, 1995, pp. 197-200). A larger coefficient on the cash flow variable in the liquidity-constrained subsample is taken as confirmation of the model.[2] Yet, as can be seen in equation (2.1) above, the parameter indicating the cost of raising funds depends on the relationship between this coefficient and the coefficient on the Q variable, and not simply on the coefficient on the cash flow variable itself. If an estimated model is consistent with this analytical framework, the ratio (c/b) should be greater for those firms facing liquidity constraints (or a higher cost of external finance).

Recent advances in corporate finance have examined how capital market imperfections, characterised as agency costs, can affect investment. Agency cost problems may be minimized by a firm's ability to "bond" a part of cash flow–for instance, by committing cash flow to debt service, and by the implicit commitment arising from common dividend strategies. In this context, using total cash flow as a measure of liquidity, as is standard practice, is clearly misleading, as the expected component of cash flow may well be precommitted to meeting financial obligations. It would thus seem that the unexpected component of cash flow would be more effective in relaxing a firm's liquidity constraint than would expected cash flow. We focus in our empirical investigation on the distinction between expected and unexpected components of firms' cash flow, and allow those components to have different effects on investment spending. If the effects of these components are indeed distinguishable, then failing to allow for the distinction will comprise potentially damaging specification error–whether or not unexpected cash flow proves to be more important than expected cash flow in influencing investment.[3] As in the model including a single cash flow measure,

[2]However, as Kaplan and Zingales (1996) point out, the relationship between investment-cash flow sensitivity and financing constraints is ambiguous.

[3]The analytical derivation of an investment model containing Q and cash flow (e.g. that of Chirinko, 1995) does not make the distinction between expected and unexpected cash flow. However, since the estimated coefficients on these components may be chosen to be identical (or statistically indistinguishable) by the data, we would argue that allowing for separate coefficients

the ratio (c/b) of the coefficient on cash flow to that on Tobin's Q should be greater for firms facing a higher cost of external finance; in our context, this should hold with respect to components of cash flow as well.

3. Data

Our main data source is the PANEL84 data set, which consists of annual data on 98 large U.S. manufacturing corporations over the period 1977-1983. These data include firms' disclosures of replacement cost values of inventory, plant and equipment, cost-of-goods-sold and depreciation, as required first by the Securities and Exchange Commission Accounting Series Release 190 and then by the Financial Accounting Standards Board Statement No. 33. On the liability side, the data include market value figures for traded debt and fair value imputations for non-traded debt, using issue-specific data on coupon, term, conversion rights, sinking fund and credit rating (see Thies and Sturrock 1987). We make use of ten quantitative measures from this dataset: additions at cost, total assets at replacement cost, gross cash flow at replacement cost (net income plus depreciation), our estimate of Tobin's q, net sales, current assets, current liabilities, financial leverage, interest expense, and an estimate of CAPM beta (generated as described in Klock et al., 1996, p.390).

We supplement these data in two ways. From Hall (1990), we obtain data on the "stock" of research and development capital. She develops these estimates as the sum of past R&D expenditures, assuming a 15 percent depreciation rate. Considering that firms are only required to report research and development expenditure if it is greater than one-half of one percent of sales, we assume expenditure for non-reporting firms–about 15 percent of the sample–is one-quarter

in implementing the model is consistent with the analytical framework.

of one percent of sales.[4]

From 1976-1982 issues of *Value Line*, we obtain data on expected cash flow: specifically, the average of the investment service's forecasts of cash flow per share times the number of outstanding shares and of net income plus depreciation, using figures from the fourth quarters of the years preceding the years of this study. In order to impute expected cash flow for companies not monitored by Value Line (about 10 percent of the sample) we impute values from a model fit over those firms for which we have complete data, making use of partial forecast data where it exists. For those firms lacking any forecast data, we assume that their average error over the sample is the same as the average error for those firms with complete data. Table 1 presents some summary statistics. Interestingly, expected cash flow is systematically higher than actual cash flow, with a mean difference of 1.5 per cent of the capital stock (or about one-fifth of actual cash flow). Both expected and unexpected cash flow measures are considerably more variable than actual cash flow. We have reestimated all models excluding the 63 firm-year observations for which expected cash flow was imputed, and find no qualitative differences arise from the restricted sample.[5]

It might be argued that this measure of cash flow–including net income rather than EBIT–is not that most commonly used in the capital investment literature; it is used in this context to provide consistency with the information on ex ante forecasts available from *Value Line.* Other studies have shown (e.g. Klock and Thies, 1995) that varying definitions of cash flow may have little effect on the

[4]We have reestimated all models removing the 166 firm-year observations for which "R&D stock" was imputed. There are no qualitative differences in the results from this restricted sample.

[5]We have also constructed estimates from a sample which excludes both R&D imputations and expected cash flow imputations. The results from this sample (which loses 188 firm-year observations present in the full sample) are not qualitatively different from those presented in the Tables.

empirical findings of capital investment models. We have estimated the models of this paper with both our measure of cash flow (net income plus depreciation) and the more commonly used measure (EBIT plus depreciation), not broken into their expected and unexpected components, and have found no material differences. Thus, the results below present only models estimated with our original measure of cash flow.

We utilized a specification search to construct a scalar measure of the cost of external finance. Observations on financial leverage, interest expense as a proportion of sales, the current ratio, the CAPM beta and total assets (as a measure of size) were considered. This set of variables, and a number of subsets, were analyzed in terms of the explanatory power of their first principal component, and the sensibility of the elements of the related eigenvector. The first three variables–financial leverage, ratio of interest expense, and the current ratio–comprised the final set chosen (descriptive statistics given in Table 1). The first principal component of that set explains 46.7% of their total variation, with positive loadings for leverage and interest expense, and a negative loading for the current ratio. Thus, larger values of this proxy for the cost of external finance are generated by firms with higher leverage, higher interest expense, and/or a lower current ratio, making it a plausible measure of the firm's creditworthiness. The sample is then divided into those firm-years in which this proxy takes on higher values than its median ($HIFLOAT$=1), and those for which it takes on lower values ($HIFLOAT$=0). A given firm is permitted to move between these subsamples in subsequent years; thus, we do not classify firms as facing relatively high or low costs of external finance, but rather classify firm-years in that way, allowing for deterioration or improvement in firms' creditworthiness. Descriptive statistics for the $HIFLOAT=\{0,1\}$ subsamples are presented in Table 2.

4. Empirical Findings

4.1. Random-Effects Estimates of the Standard Model

We do not consider pooled cross-section/time-series OLS estimates of the model, as tests for the significance of firm and time effects indicate that models excluding those effects would be seriously misspecified. Where practicable, we apply the standard random-effects estimator, as it generalizes the fixed-effects specification, attaining greater efficiency contingent on the orthogonality of regressors and the error process. Hausman tests are used to establish the appropriateness of the random-effects specification.

In column (1) of Table 3 we present random-effects estimates of the standard Q-and-cash-flow model, comparable to equation (2.1) above, in which the whole of cash flow is presumed to relax firms' liquidity constraints. Consistent with the literature, the Q and cash flow variables are lagged to avoid simultaneity bias and to allow for time-to-build. The next several columns of this table investigate the extent to which these problems are ameliorated, on the one hand, by the distinction between expected and unexpected measures of cash flow and, on the other hand, by the recognition of intangible capital. In columns (2) and (4), cash flow is split into two components: expected cash flow, equal to the *Value Line* forecast, and unexpected cash flow, equal to (actual) cash flow less expected cash flow. In columns (3) and (4), gross investment is defined as gross investment in plant and equipment plus R&D expense, and capital stock is defined as net fixed assets plus net working capital plus R&D stock.

Comparing columns (2) and (4) to columns (1) and (3), we find that, when cash flow is separated into its expected and unexpected components, expected cash flow (ECF) enters the model with a larger coefficient than unexpected cash flow (UCF). In both cases, the difference between these estimates is statistically significant; expected and unexpected cash flow measures do not have the same effect on the investment rate. Although we might expect that the coefficients on UCF should be larger than their ECF counterparts, from an econometric standpoint the message is clear: common coefficients on the two components of cash flow represent a constraint not supported by the data.

Comparing columns (3) and (4) to columns (1) and (2), we find that when research and development expenditures are capitalized, Q enters the model with a coefficient that is highly significant: indeed, of similar significance as the cash flow variable(s). Versus the traditional model (excluding intangibles), the explanatory power of the model roughly doubles.

4.2. Random-Effects Estimates by Cost of External Finance

We now separate the sample into subsamples based on $HIFLOAT$, the proxy measure of the cost of external finance. $HIFLOAT$=1 refers to those firm-years in which a high cost of external finance was encountered. We no longer consider models containing a single cash flow variable, given the strong evidence against that specification. Table 4 presents results comparable to columns (2) and (4) of Table 3: estimates of the model with R&D expensed (columns 1,2) or capitalized (columns 3,4) for $HIFLOAT$=$\{0,1\}$, respectively. Striking distinctions emerge when the Tobin's Q coefficient estimates are considered. For the $HIFLOAT$=0 subsamples, Q is significant, with sizable point estimates; for the $HIFLOAT$ =1 subsamples, Q is far from significant. Coefficient estimates for ECF and UCF are significant in all cases, but are distinguishable from one another only in the $HIFLOAT$=0 subsamples: that is, in those firm-years corresponding to the unconstrained Q model. This may well reflect the strong response of a constrained firm to available cash flow–either predictable or unpredictable–whereas an unconstrained firm might be expected to follow its optimal investment plans, with expected resources having the greater impact on those plans (as is borne out by the estimates in columns 1 and 3).

The values of the ECF and UCF coefficient estimates are considerably larger in the $HIFLOAT$=1 subsamples, as would be expected from the analytics. The estimated values of γ for both ECF and UCF are given at the foot of the Table. Recall that Chirinko (1995) found that γ for liquidity-constrained firms (those facing a high cost of external finance) should exceed the corresponding γ for unconstrained firms (a relation rarely supported in the empirical literature). In our estimates, the value of γ for $HIFLOAT$ =1 exceeds that of γ for $HIFLOAT$=0 for both ECF and UCF.

We also note that the model fits considerably better, on the one hand, for $HIFLOAT$=0 (low cost of external finance) firms; their R^2 are higher, and their standard errors of regression lower, than those for $HIFLOAT$=1 firms. On the other hand, the same ranking may be made for capitalized R&D versus expensed R&D: the models in columns (3) and (4) fit considerably better than their counterparts in terms of R^2. Several conclusions seem justified: first, division of firms' observations by their contemporaneous cost of external finance is meaningful, in that the Q-and-cash-flow model fits poorly for "liquidity constrained" firms facing a high cost of external finance. This is consistent with the extensive literature on firms' behavior subject to liquidity constraints (cf. Schiantarelli, 1995): a firm unable to capitalize on investment opportunities will not invest, irregardless of the signal generated by its Q value, weakening the causal link between Q and realized investment. Second, in the low cost of external finance subsample, the distinction between expected and unexpected cash flow is supported by the data. Third, in either subsample, the capitalization of R&D significantly improves the explanatory power of the model.

4.3. Instrumental Variables Estimates by Cost of External Finance

If the poor performance of Q is due to measurement error, an appropriate econometric technique for estimating the investment equation is instrumental variables. This involves a two-step procedure. In the first step, the poorly-measured right-hand-side variables of the behavioral relation are regressed on a set of identifying variables that are correlated with their true values and uncorrelated with the measurement error. In the second step, the predicted values from the first step are used in estimating the behavioral relation. This methodology may be used to deal with both measurement error and simultaneity bias.

Table 5 reports instrumental variables estimates of the Q-and-cash-flow model, both expensing and capitalizing R&D, by $HIFLOAT$=0 and $HIFLOAT$=1 subsamples. In these specifications, in which contemporaneous measures of Q and unexpected cash flow are incorporated into the model, the problems of endogeneity and time-to-build as well as measurement error are all addressed by the identification of these right-hand-side variables by the following set of predetermined variables: lagged Q, lagged unexpected cash flow, contemporaneous and lagged expected cash flow.[6]

Columns 1 and 2 of Table 5 contains the estimates of the specification in which R&D is expensed, while columns 3 and 4 present the equivalent estimates for capitalized R&D. We again find strikingly different estimates of the Q coefficient: significant for $HIFLOAT$=0 subsamples (while insignificant in column 2, and marginally significant in column 4), but much larger for capitalized R&D than for expensed R&D. As in Table 4, the ECF and UCF coefficients may clearly be distinguished in the $HIFLOAT$=0 (low cost of external finance) subsamples, but not in those for $HIFLOAT$=1. In terms of explanatory power, we

[6]Since the *Value Line* cash flow forecast is observed during the quarter preceding the year to which it applies, contemporaneous expected cash flow is a predetermined variable.

again find that the model fits much better in the HIFLOAT=0 subsample (in terms of R^2 and standard error of regression), and markedly better for capitalized R&D than for expensed R&D. The γ ratios for both ECF and UCF exhibit the relation predicted by Chirinko: larger γ values are associated with high cost of external finance ($HIFLOAT$=1) firms' observations. This relation holds for both expensed and capitalized R&D, but is more evident for the latter.

We cannot claim that the instrumental variables approach, allowing for contemporaneous values of Tobin's Q and unexpected cash flow, yields better estimates than those for the more traditional approach using lagged values. We present the IV estimates to demonstrate the robustness of our findings: once again, the model fits better for $HIFLOAT$=0 firms, and for samples in which R&D is capitalized. For firms facing low costs of external finance, expected and unexpected cash flow have differential effects on investment spending. In this context, the IV estimates add support to our earlier findings, and add credence to the conclusion that models fit over the entire sample would be misspecified, irregardless of estimation technique.

5. Conclusions

Our first and clearest finding is that the Q model of investment is substantially improved when firm's research and development expenditures are capitalized (as opposed to expensed). As R&D expenditures grow relative to expenditures on plant and equipment, and especially as R&D expenditures vary across industries, it is increasingly important to take them into account in econometric work.

This finding, of course, brings up the question if there are other sources of intangible capital–e.g., advertising–that should be considered in this manner, as did Klock et al. (1996). There is also a fundamental distinction which must be faced by any attempt to capture intangibles' effects on profitability: should we try to capture their effects by input-oriented measures, such as expenditures, or proxy measures of output (such as patents, in the case of R&D)? We do not deal further with this quandary here, but note that this distinction might not be so important in our sample of large manufacturing firms, which may be presumed to invest in a diversified portfolio of R&D projects, mitigating the difficulties of proxying effectiveness by expenditure.

Our second finding is that the Q model's ability to explain investment expenditures may be weakened substantially in the presence of high costs of external finance. Although we do not claim to have developed an ideal proxy for the cost of external finance, the *HIFLOAT* proxy used here draws a clear distinction between firms and years for which the Q-and-cash-flow model fits well, and those for which it does not. Although analytical findings suggest that the Q model (properly augmented by measures of liquidity) should be effective for all firms, we do not find strong support for the model among data evidencing a high cost of external finance.

A third finding is that the distinction between expected cash flow (which might not reflect "liquidity" due to precommitments) and unexpected cash flow appears important in those firm-years where the Q-and-cash-flow model fits adequately. From an econometric standpoint, the treatment of cash flow as a single, indivisible entity in the context of a Q model of investment spending would appear to be clearly inappropriate.

Table 1. Descriptive Statistics from the Panel84 Sample

	Mean	Standard Error	Minimum	Maximum
I/K	0.069	0.044	0.004	0.541
(I/K)*	0.080	0.045	0.009	0.483
Q	0.916	0.416	0.375	4.078
Q*	0.825	0.349	0.361	3.414
CF/K	0.079	0.041	-0.199	0.336
ECF/K	0.095	0.079	-0.204	1.494
UCF/K	-0.015	0.075	-1.395	0.264
(CF/K)*	0.072	0.036	-0.177	0.291
(ECF/K)*	0.085	0.063	-0.175	1.089
(UCF/K)*	-0.013	0.061	-1.017	0.229
Leverage	0.591	0.832	0.000	9.605
IntExp%Sales	1.951	1.846	0.000	22.158
Cur. Ratio, %	27.845	12.905	-26.721	67.466

Notes: Statistics are calculated from annual data, 1977-1983, for 98 large U.S. manufacturing corporations (a total of 686 observations). (I/K)*, Q*, (CF/K)*, (ECF/K)* and (UCF/K)* refer to those measures inclusive of R&D expenditures and R&D capital stock estimates.

Table 2. Descriptive Statistics for Cost of External Finance Subsamples

	$HIFLOAT$=0		$HIFLOAT$=1	
	Mean	Std.Error	Mean	Std. Error
I/K	0.072	0.040	0.065	0.047
(I/K)*	0.086	0.044	0.073	0.045
Q	0.995	0.513	0.806	0.253
Q*	0.889	0.434	0.736	0.045
CF/K	0.097	0.034	0.065	0.037
ECF/K	0.115	0.110	0.065	0.037
UCF/K	-0.019	0.108	-0.013	0.035
(CF/K)*	0.087	0.030	0.059	0.033
(ECF/K)*	0.103	0.087	0.071	0.031
(UCF/K)*	-0.016	0.086	-0.012	0.031

Notes: Statistics are calculated from annual data, 1978-1983, for 98 large U.S. manufacturing corporations. The $HIFLOAT$ variable divides the full sample on the basis of the median of a principal component into subsamples containing 343 firm-years. See notes to Table 1.

Table 3. Random Effects Estimates of the Investment Rate

	(1)	(2)	(3)	(4)
R&D	Expensed	Expensed	Capitalized	Capitalized
Constant	0.0380	0.0331	0.0360	0.0273
	(0.0072)	(0.0074)	(0.0074)	(0.0077)
Q_{t-1}	0.0090	0.0084	0.0246	0.0249
	(0.0062)	(0.0061)	(0.0071)	(0.0069)
CF_{t-1}/K_{t-1}	0.2649		0.2911	
	(0.0596)		(0.0642)	
ECF_{t-1}/K_{t-1}		0.3060		0.3642
		(0.0613)		(0.0667)
UCF_{t-1}/K_{t-1}		0.2506		0.2717
		(0.0595)		(0.0637)
S.E.R.	0.0425	0.0422	0.0412	0.0408
$Pr[CF]$		0.0129		0.0005
θ	0.3897	0.3795	0.4638	0.4513
R^2	0.125	0.139	0.199	0.225
$Pr[\tau]$	0.006	0.003	0.010	0.003

Notes: Estimates are calculated from annual data, 1978-1983, for 98 large U.S. manufacturing corporations (a total of 588 observations) and include a set of year dummies. Standard errors are given in parentheses. S.E.R. is the standard error of regression. $Pr[CF]$ is the tail probability for the test of equality between the coefficients on expected and unexpected cash flow. θ is the estimated GLS weight applied to the between-group variation, where θ=0 corresponds to OLS, and θ=1 corresponds to the fixed-effects estimator. $Pr[\tau]$ is the tail probability for the F-test that time effects are insignificant.

Table 4. Random-Effects Estimates by Cost of External Finance

	(1)	(2)	(3)	(4)
R&D	Expensed		Capitalized	
$HIFLOAT$	0	1	0	1
constant	0.0260	0.0304	0.0205	0.0326
	(0.0091)	(0.0123)	(0.0100)	(0.0126)
Q_{t-1}	0.0092	0.0071	0.0309	0.0122
	(0.0058)	(0.0127)	(0.0071)	(0.0144)
ECF_{t-1}/K_{t-1}	0.2888	0.4493	0.3213	0.5089
	(0.0846)	(0.1007)	(0.1011)	(0.1094)
UCF_{t-1}/K_{t-1}	0.2227	0.3075	0.2219	0.3553
	(0.0824)	(0.0926)	(0.0977)	(0.0952)
S.E.R.	0.0343	0.0444	0.0351	0.0416
$Pr[CF]$	0.002	0.152	0.000	0.145
θ	0.088	0.113	0.284	0.209
R^2	0.192	0.116	0.309	0.140
$Pr[\tau]$	0.000	0.814	0.000	0.810
γ_{ECF}	31.5	43.6	7.2	29.2
γ_{UCF}	24.3	63.7	10.4	41.8

Notes: Estimates are calculated from annual data, 1978-1983, for 98 large U.S. manufacturing corporations (a total of 588 observations), and include a set of year dummies. Standard errors are given in parentheses. S.E.R. is the standard error of regression. $Pr[CF]$ is the tail probability for the test of equality between the coefficients on expected and unexpected cash flow. θ is the estimated GLS weight applied to the between-group variation, where θ=0 corresponds to OLS, and θ=1 corresponds to the fixed-effects estimator. $Pr[\tau]$ is the tail probability for the F-test that time effects are insignificant. γ_{ECF} is the ratio of the point estimates of the ECF/K and Q coefficients; γ_{UCF} is the ratio of the point estimates of the UCF/K and Q coefficients.

Table 5. Instrumental Variables Estimates by Cost of External Finance

	(1)	(2)	(3)	(4)
R&D	Expensed		Capitalized	
$HIFLOAT$	0	1	0	1
constant	0.0231	0.0360	0.0187	0.0381
	(0.0063)	(0.0079)	(0.0066)	(0.0079)
Q_t	0.0082	0.0084	0.0325	0.0165
	(0.0040)	(0.0093)	(0.0046)	(0.0100)
ECF_t/K_t	0.3453	0.4045	0.3548	0.4366
	(0.0667)	(0.0791)	(0.0740)	(0.0826)
UCF_t/K_t	0.1939	0.5896	0.1474	0.6729
	(0.0719)	(0.2273)	(0.0809)	(0.2304)
S.E.R.	0.0751	0.0315	0.0243	0.0295
$Pr[CF]$	0.000	0.346	0.000	0.297
θ	0.149	0.110	0.339	0.205
R^2	0.186	0.099	0.294	0.123
$Pr[\tau]$	0.000	0.349	0.000	0.297
γ_{ECF}	23.6	70.1	4.5	40.9
γ_{UCF}	41.8	48.2	10.9	26.5

Notes: Estimates are calculated from annual data, 1978-1983, for 98 large U.S. manufacturing corporations (a total of 588 observations), and include a set of year dummies. Instruments include Q_{-1}, ECF/K, ECF_{-1}/K_{-1}, UCF_{-1}/K_{-1} and the year dummies. Standard errors are given in parentheses. S.E.R. is the standard error of regression. $Pr[CF]$ is the tail probability for the test of equality between the coefficients on expected and unexpected cash flow. θ is the estimated GLS weight applied to the between-group variation, where θ=0 corresponds to OLS, and θ=1 corresponds to the fixed-effects estimator. $Pr[\tau]$ is the tail probability for the F-test that time effects are insignificant. γ_{ECF} is the ratio of the point estimates of the ECF/K and Q coefficients; γ_{UCF} is the ratio of the point estimates of the UCF/K and Q coefficients.

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