WORKING PAPERS

Klaus Gugler, Dennis C. Mueller and B. Burcin Yurtoglu

Marginal Q, Tobin's Q, Cash Flow and Investment

May 2000

Working Paper No: 0002

DEPARTMENT OF ECONOMICS

UNIVERSITY OF VIENNA

MARGINAL Q, TOBIN'S Q, CASH FLOW AND INVESTMENT*

KLAUS GUGLER, DENNIS C. MUELLER AND B. BURCIN YURTOGLU

Abstract:

Many studies of the determinants of investment use Tobin's *q* to control for the investment opportunities of a firm. Tobin's *q* roughly measures the average return on a firm's capital anticipated by the market. More relevant for investment decisions, however, is the marginal return on capital. In this paper we estimate investment and R&D equations using a measure of marginal *q*. We use marginal q to identify the existence of cash constraints and managerial discretion, and as a separate explanatory variable. For a sample of 562 U.S. firms observed over the 1977-1996 period we present evidence confirming the existence of both cash constraints in some companies and managerial discretion in others.

Keywords: Investment, Cash Flow, Tobin's q, Marginal q, Asymmetric Information, Managerial Discretion

JEL Classification: G31, G32, L21, O16

* The research in this article was supported in part by the Austrian National Bank's Jubiläumsfonds, Project 8090.

In the neoclassical theory of investment as developed by Dale Jorgenson [1963, 1967], the amount of investment a firm undertakes is dependent on its cost of capital and current sales. This approach can be criticized on the grounds that today's investment is undertaken to produce *tomorrow's* output and what one really wants in the model is a measure of future sales. Yehuda Grunfeld [1960] was the first to suggest using the firm's current market value as a proxy for future sales, but most of the literature has employed Tobin's q, the ratio of market value to current capital stock [Tobin, 1969].

Tobin's q theory assumes that firms are price takers operating in perfectly competitive industries.[1] Under these assumptions differences in ratios of current market values to current capital stocks imply differences in returns on additions to capital stocks, and should be directly related to differences in investment. When firms operate in imperfectly competitive markets, however, some earn rents and these rents are capitalized in their market values. Differences in qs may be dominated by differences in *inframarginal* returns on capital, and thus may be poor predictors of investment. Tobin's q reflects the *average* return on a company's total capital, but what is relevant for investment is the *marginal* return on capital. What is needed to explain investment is a marginal q. One of the contributions of this paper is to construct and employ such a variable in an investment equation.

Both the neoclassical and standard q-theories of investment assume that managers maximize shareholder wealth, and thus investment is undertaken to the point where its return equals the firm's cost of capital. In such a neoclassical world, a firm's investment should be independent of the size of its cash flow. If its optimal investment is less than its cash flow, it pays dividends, if it is greater than its cash flow, the firm raises funds in the external capital market. A literature dating back some 40 years has found a consistent and often strong relationship between company cash flows and their investments, however.[2] Two, quite different explanations for this relationship have been given: One posits the existence of asymmetric information. Some firms have attractive investment opportunities, but the capital market is unaware of them. If the firm is short on cash, its managers may pass up these investment opportunities rather than issue shares to finance them, since the firm's current share price is less than it would be, if the market could correctly evaluate the firm's investments.[3] When this occurs, the returns on the investments that the company actually makes *exceed* its cost of capital, and it *underinvests* from the point of view of its shareholders.

The second explanation for a positive relationship between cash flow and investment posits the existence of managerial discretion. Managers obtain financial and psychological gains from managing a large and growing firm and thus investment beyond the point that maximizes shareholder wealth. When this occurs, the company's returns on investment are *less* than its cost of capital, and it *overinvests* from the point of view of its shareholders.[4]

Given that these two hypotheses about a cash flow/investment relationship make totally opposite predictions about company returns on investment relative to their costs of capital, a natural way to test for the presence of their predicted behavior is to divide a sample of firms into those with returns on investment less than their costs of capital, and those with returns greater than their costs of capital.[5] We adopt this approach.[6] We first estimate for a sample of 562 U.S. companies the ratios of each company's return on investment to its cost of capital over the 1979-1996 period. These estimates are used to divide the sample into companies with returns on investment greater than or equal to their costs of capital, and companies with returns less than their costs of capital. Cash flow/investment equations are then estimated for each subsample. If the first subsample contains a substantial fraction of firms with asymmetric information problems, then evidence of a positive investment/cash flow relationship in this subsample can be interpreted as support for this hypothesis. A positive investment/cash flow relationship in the second subsample is consistent with the managerial discretion hypothesis.

Although Tobin's q is likely to be a poor proxy for the returns on a company's investments for the reasons given above, it can be a good indicator of the presence of asymmetric information for firms with returns on investment greater than their costs of capital, and of the degree of managerial discretion for firms with returns on investment less than their costs of capital. Thus, Tobin's q appears in our investment equations, but not for the reasons usually given to justify its inclusion, but rather as a further test of the two theories that posit a positive relationship between cash flow and investment. As we shall see, the two theories make somewhat different predictions as to the relationship between q and investment in a cash-flow model of investment, and thus q's performance in an investment equation can be a good test of the theories.

Purchases of plant and equipment are not the only investments companies make, and any theory that can explain this form of investment should be able to explain the others. We shall, therefore, also estimate R&D equations for our different subsamples of firms using cash flow and q as explanatory variables.[7]

During the 1980s, the United States experienced a wave of mergers that included a significant number of "hostile takeovers." Many targets of these hostile takeovers were managed by people who had previously undertaken mergers and other investments which "destroyed shareholder value," and the stated purpose for the takeover was to replace these managers. That is to say, many of the managers of the targets of the hostile takeovers had behaved prior to the takeover as the managerial discretion/growth maximization hypothesis predicts. Thus, the merger wave of the 1980s quite possibly led to a tightening of the takeover constraint on managers, and a reduction in their discretion to invest internal cash flows for the purpose of pursuing growth. The wave of spin-offs in the early 1990s, emphasis on "downsizing" and "returning to core competences," and renewed interest in "shareholder value" as evidenced by share buy backs are all consistent with the hypothesis that the existence and/or exercise of managerial discretion declined during the 1980s and 1990s.[8] We offer evidence in support of this hypothesis.

We proceed as follows. Section I reviews various theoretical arguments for including Tobin's q and cash flow in an investment equation. In it we also explain the methodology for calculating a marginal q and the ratio of a firm's return on investment (r) to its cost of capital (i), a ratio that we call c, $c = r/i$. As we shall see, this c is in effect an estimate of a marginal q. In section II we briefly describe the data set and the procedures used to make the estimates. The results are presented in section III, with conclusions drawn in the final section.

I. Theoretical Issues

A. The *q*-theory of investment

The market value of a company at time 0, M_0, equals the present discounted value of its future profits, π_t

(1) $$M_0 = \sum_{t=1}^{\infty} \frac{\pi_t}{(1+i_t)^t}$$

where i_t is the firm's discount rate at time t. If we assume a constant discount rate i and a constant growth rate g for profits, the firm's market value becomes

(2) $$M_0 = \sum_{t=1}^{\infty} \frac{\pi_0 (1+g)^t}{(1+i)^t} = \frac{\pi_0}{(i-g)}$$

assuming $i > g$. Defining ρ as the firm's return on capital and dropping the 0 subscript, we obtain

(3) $$M = \frac{\pi}{i-g} = \frac{\rho K}{i-g}$$

From (3) we can derive an expression for q

(4) $$q = \frac{M}{K} = \frac{\rho}{i-g}$$

In a steady state of zero growth and perfect competition, $g = 0$, $\rho = i$, and $q = 1$. The firm's only investment will be to replace depreciating capital stock. If either $g > 0$ or $\rho > i$, then $q > 1$ and the firm has an incentive to expand its capital stock.

This is the logic underlying the q-theory of investment.[9] It rests crucially on the assumptions of perfect competition and that firms are price takers, which imply that marginal and average ρ are equal, and $\rho = i$ in equilibrium. When firms are not price takers and markets are imperfectly competitive, however, marginal and average returns on capital do not coincide and equilibria may exist in which a firm's average return on capital differs from its marginal return. The problem is illustrated in Figure I. The capital stocks for two firms are measured along the horizontal axis. The figure has been constructed, so that each firm has the same existing capital stock, K_0, and the same desired capital stock, K_1, which is determined by the intersection of the marginal revenue schedules, mr_i, with the assumed identical cost of capital *i*. The average return on capital for each firm is the integral of the area under the *mr* line divided by its capital stock. Although both companies have the same optimal levels of investment, $K_1 - K_0$, the returns on capital for firm 2 are obviously much greater than for firm 1, and thus so too will be 1's market value and *q*-ratio. To predict the investments of these two companies more accurately, we need to measure their *marginal* returns on capital relative to their costs of capital. Such a measure is developed in the next subsection.

B. The *c*-theory of investment

Let I_t be a firm's investment in period *t*, C_{t+j} the cash flow this investment generates in $t + j$, and i_t the firm's discount rate in *t*, then the present value of this investment is

(5) $$PV_t \equiv \sum_{j=1}^{\infty} \frac{C_{t+j}}{(1+i_t)^j}.$$

We can define for any i_t, a permanent return, r_t, on the investment I_t, which creates an equivalent present value to that defined by (5).

(6) $$PV_t = \frac{I_t r_t}{i_t} = c_t I_t$$

where $c_t = r_t / i_t$. A firm which maximizes shareholder wealth undertakes all investments for which c_t, as defined by (6), is equal to or greater than one. Estimates of c_t can thus be used to predict firm investment without confounding marginal and inframarginal returns on capital. We now describe how separate *c*s can be obtained for each firm.

The market value of the firm at the end of period *t* can be defined as,

(7) $$M_t \equiv M_{t-1} + PV_t - \delta_t M_{t-1} + \mu_t$$

where PV_t is the present value of the investment made during *t*, δ_t the depreciation rate for the firm's total capital, and μ_t the market's error in evaluating M_t. If we assume that the capital market is efficient, the error term in (7) will have the usual properties assumed in regression analysis, and (7) can be used to estimate both δ and *c* under the assumption that they are constant across firms or over time, or both[10]. Replacing PV_t in (7) with $c_t I_t$, and rearranging yields

(8) $$c_t = \frac{M_t - (1-\delta) M_{t-1}}{I_t}$$

Equations (7) and (8) incorporate the assumption that the market value of a firm at the end of year *t-1* is the present discounted value of the expected profit stream from the assets in place at *t-1*. Changes in market value are due to changes in assets in place as a result of investment and depreciation. To calculate the marginal Tobin's *q*, c_t, one needs an estimate of the depreciation rates of a firm's total capital, δ, where the value of this capital is measured by the market value of the firm. The depreciation rate depends on the composition of tangible and intangible assets in total market value, which can in theory be broken down into its separate components: (1) its stock of physical capital (plant and equipment), (2) intangible capital due to past advertising, and (3) due to past R&D, and (4) goodwill capital. A 10 percent depreciation rate is reasonable for the first and third stocks, is probably too low for the second, and too high for the fourth. As a first approximation for δ_t we assume a constant $\delta = 0.075$ to calculate the c_ts.[11]

The c_ts calculated with the use of (8) are thus essentially *marginal* Tobin's *q*s defined on all investments made in *t*, and are more appropriate candidates as measures of company investment opportunity than are the more familiar Tobin's *q*s.

The methodology can be used to obtain a *c* for a given time period. Using (7) to replace the first right hand term in successive periods yields a multi-period version of (7),

(9) $$M_{t+n} = M_{t-1} + \sum_{j=0}^{n} PV_{t+j} - \sum_{j=0}^{n} \delta_t M_{t+j-1} + \sum_{j=0}^{n} \mu_{t+j}$$

Using eq. (6), we can calculate a weighted average *c* with each year's investment as weights

(10) $$\bar{c} = \frac{\sum_{j=0}^{n} c_{t+j} I_{t+j}}{\sum_{j=0}^{n} I_{t+j}} = \frac{\sum_{j=0}^{n} PV_{t+j}}{\sum_{j=0}^{n} I_{t+j}}$$

Dividing (9) by $\sum_{j=0}^{n} I_{t+j}$, substituting from (10) and rearranging yields

(11) $$\bar{c} = \frac{M_{t+n} - M_{t-1}}{\sum_{j=0}^{n} I_{t+j}} + \frac{\sum_{j=0}^{n} \delta_{t+j} M_{t+j-1}}{\sum_{j=0}^{n} I_{t+j}} - \frac{\sum_{j=0}^{n} \mu_{t+j}}{\sum_{j=0}^{n} I_{t+j}}$$

The hypothesis of stock market efficiency implies the $E\left(\mu_{t+j}\right) = 0$ for all *j*, and thus that the last term on the right in (11) becomes small relative to the other two terms as *n* grows large. The market value of the firm and investment are both observable. Therefore, $\bar{c}$ can be calculated to a close approximation using (11) for any assumed set of δ_{t+j} when *n* is large. This $\bar{c}$, the weighted average of the ratio of returns on investment to the cost of capital, is used to discriminate between the hypothesis regarding investment behavior.

C. The Determinants of Investment with Asymmetric Information

Under the neoclassical theory of investment, a firm invests to the point where its marginal returns on investment equal its cost of capital. A firm with marginal returns, *mr*, in Figure II (a) would invest I_O. Since this exceeds its internal cash flows, *CF*, this firm would raise the difference between I_O and *CF* on the external capital market. A firm with marginal returns, mr_I, in Figure II (b) would again invest I_O. Since this falls short of its internal cash flows, *CF*, this firm would either pay the difference between I_O and *CF* out as dividends or use these funds to purchase its own shares. Under the neoclassical theory a firm's marginal returns on investment would always equal its cost of capital.

These predictions follow from the neoclassical theory of Modigliani and Miller [1958]. They do not necessarily hold when the kind of asymmetric information posited by Myers and Majluf [1984] or Stiglitz and Weiss [1981] is present, even when managers seek to maximize shareholder wealth. When the external capital market cannot accurately evaluate the returns on a company's capital and investment, the firm may find it difficult to raise as much capital as it needs to finance all investment projects promising returns greater than *i*, and $mr > i$, and thus $\bar{c} > 1$. In the extreme case, the firm is unable to raise any capital externally, and its investment is limited to its internal cash flows. Our first prediction for companies for which $\bar{c} \geq 1$ is, therefore, that their investment should be positively associated with their cash flows.[12]

The greater the difference between *mr* and *i*, the greater the incentive a firm has to raise capital externally to finance its investments, even when its cost of external finance exceeds *i*. Thus, our second prediction for firms with $\bar{c} \geq 1$ is that their investment should be positively associated with *c*.

Under the asymmetric information hypothesis companies pass up investments for which $mr > i$ because their common shares are currently undervalued given the firm's returns on both capital and investment. Such an undervaluation seems more likely, the lower the value that the market places on the firm's existing units of capital. Thus, if some firms with $\bar{c} \geq 1$ are subject to asymmetric information problems, we also expect a positive correlation between Tobin's *q* and investment. The reason for this expected positive association is *not* because *q* accurately measures investment opportunities as assumed in the *q*-theory, however, in our model *c* plays that role. Instead, a positive relationship between *q* and investment for firms with $\bar{c} \geq 1$ is expected, because the ease with which the firm can raise capital externally should vary directly with *q*. By the same logic a firm with a high *q* should be less dependent on its internal fund flows to finance its investments. We test this implication of the asymmetric information hypothesis by including an interaction term between *q* and cash flow in the investment equation. The predicted sign on this interaction term is negative. The higher *q* is, the weaker the predicted relationship between cash flow and investment for firms with $c \geq 1$.

The reader might be concerned that we have assumed capital market efficiency in estimating individual c_ts and their weighted average, $\bar{c}$, and yet seek to test a hypothesis that presumes asymmetric information between managers and the capital market. Here it should be noted that we categorize companies as being *potentially* subject to asymmetric information problems based on their weighted average return on investment over the 18 years in our panel data. Our procedure for calculating this average c uses the change in the firm's market value over the full 18 year period. The market could incorrectly evaluate a firm's returns on investments in some years and our $\bar{c}$ would still be an accurate measure of its average c_t, if the market corrected its mistake in a later period. In using $\bar{c}$ to classify firms, therefore, we are implicitly assuming that any asymmetry of information about a firm's investment opportunities disappears by the end of our 18 year sample period. We shall actually test whether this prediction is supported by the data (see subsection E).

D. The Determinants of Investment with Managerial Discretion

When $\bar{c} < 1$ managers have overinvested from the point of view of the shareholders. Such overinvestment is predicted by the hypothesis that managers have discretion to pursue their own goals and use this discretion to expand their firms.

Managerial discretion has two sources: (1) slackness in monitoring by shareholders and the market for corporate control, and (2) non-binding resource constraints. In a perfectly competitive world, managers would not be able to finance investments with $mr < i$ for very long without risking going out of business. The product market would play an effective monitoring role, even if the stock market could not. When the discipline of the product market is weak, however, and managers have greater cash flows than needed to finance what would be the optimal investment level from the point of view of their shareholders, they use some of the "extra cash" they have to finance additional investment. This is the situation depicted in Figure II (b). Our first prediction for firms with $\bar{c} < 1$ is thus that their investments are positively related to their cash flows.[13]

If all firms had the same cost of capital and marginal returns on investment schedule, say i and mr_2 in Figure II (b), mr would vary inversely with investment, and we would predict a *negative* relationship between c and investment for the subsample of companies with $\bar{c} < 1$. But the assumption that all firms face the same *mr* schedule and have the same i is untenable. With different *mr* schedules and is, there is no reason to expect any relationship between c and investment. For example, if firms 1 and 2 in Figure II (b) had the same i and invested amounts I_1 and I_2, respectively, their cs would be identical ($c = j/i$), although their investments would differ. We predict, therefore, that c and I are unrelated in the subsample of firms for which $\bar{c} < 1$.

Both the threat of a hostile takeover and the resource constraints on managers should be lower for firms with relatively high share prices. We thus predict that managerial discretion increases with Tobin's q, and expect a positive relationship between investment and q for companies with $\bar{c} < 1$. Since managerial discretion manifests itself as overinvestment out of cash flows, the relationship between cash flow and investment should grow *stronger* as managerial discretion increases. We thus again include an interaction term between q and cash flow in the investment equations, as we did for firms with $\bar{c} \geq 1$. For firms with $\bar{c} < 1$, however, the predicted coefficient on this interaction term is positive, the opposite sign from that predicted under the asymmetric information hypothesis.

E. Changes over Time

We use equation (11) to calculate a separate $\bar{c}$ for each of the 562 companies in our sample for the period 1977 to 1996. Each company's $\bar{c}$ can be regarded as a *weighted average* of its individual year cs over the 18 year period with the annual investments as weights. We categorize companies as being likely to asymmetric information problems or managerial discretion on the basis of these $\bar{c}$s. Thus, we test for the asymmetric information hypothesis in the subsample of firms for which we compute a $\bar{c} \geq 1$ over the 18 year period.

If a firm's investments continually have returns greater than its cost of capital, however, the capital market should adjust its evaluation of the firm's investment opportunities upward, and the firm's difficulties in raising capital externally should decline. We thus predict a decline over the course of our sample period in the importance of both cash flow and Tobin's q as explanatory variables in the investment equation for firms with $\bar{c} \geq 1$.

As noted above, the increased number of hostile takeovers over the course of the 1980s, the subsequent spin-offs, downsizing, de-diversification and stock buy backs all are consistent with the hypothesis that managerial discretion and empire-building declined over our sample period.[14] We thus also predict a decline in the size and significance of both cash flow and Tobin's q in the investment equation for firms with $\bar{c} < 1$.

F. Summary of Hypotheses

The basic equations that we shall estimate for capital investment in year t, I_t, and R&D, R_t, are as follows:

(12) $$\frac{I_t}{K_{t-1}} = a + b\,c_{t-1} + c\,\frac{CF_{t-1}}{K_{t-1}} + d\,q_{t-1} + e\,\frac{CF_{t-1} \cdot q_{t-1}}{K_{t-1}} + \mu_t$$

(13) $$\frac{R_t}{K_{t-1}} = f + g\,\frac{CF_{t-1}}{K_{t-1}} + h\,q_{t-1} + l\,\frac{CF_{t-1} \cdot q_{t-1}}{K_{t-1}} + \mu_t$$

These resemble cash-flow/investment equations from other studies except for the inclusion of our measure of marginal q, c_t, and the interaction term between q and cash flow. All of the independent variables are lagged one period to avoid their being partly endogenous.

We have classified firms for the purpose of testing the different hypotheses using cs calculated over 18 years. A company's investment opportunities can be expected to vary from year to year, however, and thus to predict a firm's investment in a given year, we need a short run estimate of returns. We thus use a one period c, namely the change in a company's market value in the previous year divided by its total investment in that year (see eq. (8)). Since both share prices -- and thus market values-- and investment are highly volatile, these one period c_t s vary considerably over the sample period. For example, the variance in c_t is 15.6 times the variance in q (see Table II). Choosing a variable with such a large variance to explain investment puts the theory to a severe test.

While we predict that this measure of the short run attractiveness of investment will be significantly related to investments in plant and equipment for the subsample of companies for which the asymmetric information hypothesis applies, we do not make this prediction for the R&D equation. There are significant transaction costs in expanding and contracting R&D activities, and we do not expect R&D outlays to be responsive to short run changes in returns on investment. We thus exclude c_{t-1} in the R&D equation. Table I summarizes the predictions derived from the different theories. For completeness, we include the predictions from the neoclassical/q-theory, however, we exclude our predictions over time. We have placed a zero in the table wherever the theory makes a clear prediction of no relationship, as for example for cash flow under the neoclassical theory, and a question mark where there is no obvious relationship from the underlying hypothesis.

II. Methodology and Data

To use (8) and (11) we need data on the market value of each firm and its investments. The market value of a firm at the end of year t, M_t, is defined as the market value of its outstanding shares at the end of year t plus the value of its outstanding debt. Since this number reflects the market's evaluation of the firm's total assets, we wish to use an equally comprehensive measure of investment. Accordingly we define investment as

$$(14) \qquad I = \textit{After tax profits} + \textit{Depreciation} - \textit{Dividends} + \Delta \textit{Debt} + \Delta \textit{Equity} + R\&D + ADV$$

where $\Delta Debt$ and $\Delta Equity$ are funds raised using new debt and equity issues. Since R&D (COMPUSTAT item 46) and advertising (ADV, item 45) are also forms of investment that can produce "intangible capital" which contributes to a company's market value, we add them to investment to obtain a measure of the firm's additions to its total capital.

Tobin's q is defined as the ratio of the market value of a firm to its total assets (item 6) where the market value of the firm equals the market value of common equity (items 199 (share price at the end of the fiscal year) times 25 (common shares outstanding)) plus the book value of preferred stock (in order and as available items 56, 10, 130) plus the book value of total debt (which is the sum of total short term debt (item 9) and total long term debt (item 34)).[15] Cash flow is the sum of after tax profits (item 18) and depreciation (item 14) minus total dividends (item 21 plus item 19 if available). We adjust the cash flow measure by adding the portion of R&D that is expensed for tax purposes.[16] Our measure for the capital stock is net fixed assets (item 8, the cost net of accumulated depreciation of property, plant and equipment). All variables are deflated by the Consumer Price Index and are expressed in real 1987 U.S. dollars.

Using equation (11) to calculate the full period $\bar{c}$[17] requires the availability of market value and investment figures for the 1977 to 1996 period which reduces the number of firms to 562 from a potential of 5140 firms.

The data are taken from the 1996 version of the Compustat data set. This data set contains accounting and financial data on 9,862 active companies with listed stocks in North America starting in 1977. We exclude 4,722 companies in financial and service industries, because the nature of capital and investment in these industries is so different from that in other industries. After the construction of our basic variables and after the elimination of some obvious outliers[18] in the data, the number of companies reduces to 562. The data series used in this study ends in 1996. Table II reports summary statistics and correlations of the variables that we use throughout the paper.

Before turning to our main findings, a comment on the numbers in Table II is warranted. The simple correlation between the ratio of cash flow to capital stock and Tobin's q is fairly high – 0.183. This is not surprising, since both are measures of *average* returns on capital. The correlations between the cash flow variable and our two measures of marginal q, on the other hand, are quite low – 0.019 and 0.06. These low correlations suggest that any relationship that we find between cash flow and investment in our sample is unlikely to come about, because cash flow is proxying for a firm's investment opportunities, since marginal q is a measure of these.[19]

III. The Findings

A. Main Results

Table III presents the results for investment in plant and equipment with observations pooled over the 18 year time period. For the grand sample, all four coefficients on the explanatory variables are highly significant. The positive and significant coefficient on cash flow is, of course, inconsistent with the neoclassical/*q*-theory hypothesis. Our measure of marginal *q*, c_{t-1}, takes on a positive sign as predicted, with a *t*-value over five.

Equation (2) presents the results for the subsample of companies with $\bar{c} \geq 1$. The coefficients on both c_{t-1} and q_{t-1} are positive and significant. Given that c_{t-1} is included to capture the attractiveness of a company's investment opportunities, we interpret the positive coefficient on q_{t-1} as an inverse measure of the importance of asymmetric information for a company. Holding cash flow constant, companies with high *q*s invest more, because they have less difficulty raising cash externally. This interpretation of the role played by *q* in the investment equation is reinforced by the performance of the *q*/cash-flow interaction term. Its negative and significant coefficient implies that the sensitivity of a company's investment to the level of its cash flow declines as the value that the market places on its existing capital rises, and thus as its access to external capital improves. Similarly, the link between *q* and investment grows weaker, the greater the firm's cash flows, and thus the less important access to the external capital market becomes.

Cash flow also has a positive coefficient in the equation for firms with $\bar{c} < 1$. In contrast with the subsample where $\bar{c} \geq 1$, the interaction term between *q* and cash flow is *positive* and significant for firms with $\bar{c} < 1$. We hypothesized that Tobin's *q* would proxy for managerial discretion in this subsample. Equation 3 is consistent with this hypothesis. For firms with $\bar{c} < 1$, the marginal impact of cash flow on investment increases as *q* increases. Tobin's *q* also has an independent positive and significant impact on investment. Taken together these results offer considerable support for the managerial discretion hypothesis. Many managers of firms with relatively high share prices and cash flows appear to take advantage of the discretion they have over the allocation of these funds to expand their companies beyond the point that is optimal from the point of view of their shareholders.

The estimates for equations 2 and 3 imply almost identical marginal impacts of cash flow on investment for the two subsamples ($\partial I_t / \partial(CF_{t-1}/K_{t-1}) = .134$ for the $\bar{c} \geq 1$ subsample, and $\partial I_t / \partial(CF_{t-1}/K_{t-1}) = .129$ for $\bar{c} < 1$ firms, when q is evaluated at the respective sample means, see Table IV). Firms that seem to fit the cash-constraints hypothesis or that appear to have overinvested over the 1979-1996 period spend on average 13 percent of any additional cash flow on capital investment.

In contrast, the marginal impacts of q_{t-1} on investment are quite different between the two subsamples ($\partial I_t / \partial q_{t-1} = .025$ for $\bar{c} \geq 1$ companies, and .082 for $\bar{c} < 1$ firms, with CF_{t-1}/K_{t-1} evaluated at its subsample means. The difference is significant at the one percent level.[20]). Increases in q appear to have a greater impact on managerial discretion and managers' use of their discretion than on easing external capital market constraints for firms that may be cash constrained.

We have stressed the logical superiority of a measure of *marginal q* over average q as an index of the firm's investment opportunities. Our measure of marginal q, c_{t-1}, has a positive and significant coefficient in both the capital investment equation estimated over the full sample of companies, and in the subsample with $\bar{c} \geq 1$, where investment behavior may be influenced by cash constraints. We did not predict a relationship between marginal q and investment, however, for those companies that appear to be overinvesting, nor do we find one. The coefficient on c_{t-1} is insignificant for $\bar{c} < 1$ companies, despite this subsample having 4534 observations, 50 percent more than the $\bar{c} \geq 1$ subsample. Moreover, a t-test reveals that marginal q has a significantly (five percent level) greater impact on investment for $\bar{c} \geq 1$ firms as compared to $\bar{c} < 1$ firms. What drives the investments of companies in our second subsample is not the height of their investment opportunities on the margin, but their resources and discretion to pursue additional investment.[21]

We gave reasons above for possibly expecting a weakening of the asymmetric information problem and/or the extent of managerial discretion over time. Such a development should manifest itself as a decline in the coefficients on either cash flow or q over time. There is no reason to expect, however, that these coefficients will eventually turn negative. To avoid this possible implication, therefore, we did not interact each term with t as is the common practice, but rather with its reciprocal. This method of allowing for time-related changes in coefficients imposes the reasonable restriction that the magnitude of the changes itself declines over time, and the coefficients on each variable asymptotically approach given values.

Equations 4-6 in Table III report the results, omitting those interaction terms with $1/t$ that are statistically insignificant. The easiest way to understand the results is again to compute the implied partial derivatives for lagged cash flow and q at both the start of our sample period, 1979 ($t = 1$), and in the long run ($t \rightarrow \infty$). These are given in Table IV. For firms with $\bar{c} \geq 1$, there was not a significant change in the coefficients on c_{t-1}, q_{t-1}, or on the q_{t-1}-cash flow interaction term. Marginal q has the same positive and significant impact on investment throughout the period. The marginal impact of a change in lagged q is also the same throughout the period. It is positive for firms with $\bar{c} \geq 1$, but declines as cash flow increases as implied by the asymmetric information hypothesis.[22]

Evidence of a weakening of the asymmetric information problem is found in the changes of the marginal impact of cash flow on investment over time. Evaluated at the subsample mean of q_{t-1}, the partial derivative of investment with respect to cash flow declines from .402 at the beginning of the sample period to a long run projected value of only .053.

There is also some evidence of an attenuation of managerial discretion during the sample period. Our estimate of the coefficient on the q-cash flow interaction term are positive and quite large for the beginning of the sample period as we predicted under the managerial discretion hypothesis. It declines with time and actually approaches a negative value, although small in absolute value, in the long run. The estimated marginal impacts of cash flow and q on investment for $\bar{c} < 1$ companies both decline, when evaluated at the subsample means for the appropriate interaction variable (see Table IV).

The decline in the marginal impact of lagged cash flows is rather modest, however, and its estimated marginal impact as well as that of lagged *q* remains positive and significant even in the very long run. The impact of managerial discretion on corporate investment may have weakened over the course of the 1980s, but it did not totally disappear.

We predicted that the investments of firms characterized by managerial discretion motives would be unrelated to the marginal returns on these investments. This was true at both the beginning and the end of the period.

Part B of Table III presents the results when R&D is the dependent variable. The equations are identical to those for which investment is the dependent variable except that c_{t-1} has been omitted, as R&D is not expected to respond to short-run estimates of returns on investment. The results are quite similar to those reported for capital investment. Looking first at the three equations where no time trends are included, we see that for $\bar{c} \geq 1$ firms, the coefficients on both cash flow and *q* are positive and significant. Unlike for the capital investment equation, however, the sign on the interaction term is also positive, although insignificant and significantly smaller than for $\bar{c} \geq 1$ firms. Support for the asymmetric information hypothesis over the predictions of neoclassical theory can still be claimed on the basis of the very large and highly significant coefficient on cash flow in the R&D equation for $\bar{c} \geq 1$ firms.

In the $\bar{c} < 1$ subsample, the coefficients on all three variables are positive and significant as predicted under the managerial discretion hypothesis, although the coefficient on q_{t-1} is only significant at the 10 percent level (one-tailed test). In addition to being of the correct sign and significant, the coefficients on cash flow and on the *q*-cash flow interaction term are quite large, and imply a marginal impact of cash flow on R&D spending for $\bar{c} < 1$ firms of .266, an estimate of cash flow's impact that is double that for the $\bar{c} \geq 1$ firms. Thus, the pattern of results for R&D in equations 2 and 3 of Table III also offers considerable support for both the asymmetric information and managerial discretion hypotheses.

Equations 4-6 in Part B include the significant interaction terms with *1/t*. For the subsample with $\bar{c} \geq 1$ again only the interaction term with lagged cash flow is statistically significant. Its inclusion causes the interaction term between lagged *q* and cash flow to become significant, while remaining positive. This result contradicts our prediction for the asymmetric information hypothesis. The dramatic decline in the marginal impact of cash flow on R&D from .4 at the beginning of the sample period to a project .053 in the long run is, on the other hand, quite supportive of the prediction that asymmetric information should disappear with time. No significant time trends were observed in *q*s impact on R&D for the $\bar{c} \geq 1$ subsample. Thus, the coefficients in Table III for the $\bar{c} \geq 1$ firms imply that they begin the sample period looking like firms subject to asymmetric information problems, but are projected as time elapses to behave more and more like companies that fit neoclassical/*q*-theory, with *q* strongly related to R&D spending, and cash flow rather weakly related.

The estimates for Eq. (6) in Part B of Table III imply positive coefficients on the cash flow/*q* interaction term at both the beginning of the sample period and in the very long run, and thus are consistent with our prediction. The estimates also imply a substantial decline in the interaction term's coefficient from .20 at the beginning of the sample period to .014 in the long run. This change implies a decline in managerial discretion over time. A weakening of managerial discretion is also implied by the estimated decline in the cash flow's marginal impact on R&D from .337 in 1979 to .243 in the long run (Table IV).

No decline over time in lagged *q*'s effect on R&D is apparent in Table III, however -- quite the contrary. The marginal impact of *q* rises from near zero in 1979 to .067 in the long run. Thus, although the results in Table III suggest some attenuation of managerial discretion's impact on R&D spending after 1979, as was true for capital investment, all long-run projected coefficients for the $\bar{c} < 1$ firms are still consistent with our predictions for this hypothesis -- a positive and large marginal impact of cash flow, a positive and large impact of lagged *q*, and a positive, albeit modest, interaction effect.

B. Additional Splits and Robustness

Tables V and VI present various robustness checks. Columns 2 to 4 in Table V present investment equations including an accelerator term. This term is highly significant, nevertheless, the basic results concerning our hypotheses are not altered.

In Tables III and IV separate coefficients on the deflated intercept term ($1/K_{t-1}$) were estimated for each two-digit SIC industry. In the investment equation this amounts to assuming different depreciation rates for each industry, while in the R&D equation the procedure amounts to controlling for differences in R&D intensity across industries. We also estimated the basic equations with fixed effects terms, thus allowing for firm-specific rates of depreciation in the investment equation and fixed differences in R&D intensity across firms. The results were qualitatively similar to those reported, and are presented in columns 5 to 10 in Table V for the basic model. Once we control for unobserved heterogeneity in investment spending across firms, the coefficient for our marginal q variable in the $\bar{c} < 1$ subsample also becomes significant (t = 2.30). However, the coefficient is again much smaller than for the $\bar{c} \geq 1$ subsample and the difference is again significant at least at the five percent level. These results suggest that unobserved firm characteristics capture differences in managerial discretion across firms, and once these differences in managerial discretion are controlled for, the investment of these firms also varies with marginal q, albeit to a lesser extent than for $\bar{c} \geq 1$ firms.[23]

Many studies[24] have hypothesized that firm size is an important determinant of either asymmetric information or managerial discretion, or both. Smaller firms may face higher asymmetry of information and transaction costs implying a greater reliance on internal funds. Larger firms may have lower threats of takeover and thus be more susceptible to discretionary managerial spending. Table VI, Panel A splits the sample into small and large firms based on their median sales. In columns 4 and 5, the sample is further divided into small firms with $\bar{c} \geq 1$ and large firms with $\bar{c} < 1$ firms.[25] These two subsamples might be expected to exhibit the greatest degrees of asymmetric information and managerial discretion. The results reinforce the earlier findings. Marginal q's impact on investment is much larger and significantly different for small firms than for large firms, the cash flow/q interaction term is negative and significant for small firms and positive (although insignificant) for large firms, and cash flow has a larger (and significantly different) impact on investment for large firms than for small firms. Columns 4 and 5 show that these differences are most pronounced, when we additionally split by mean marginal q: For small/high $\bar{c}$ firms, marginal q is a positive and significant determinant of investment, whereas for large/low $\bar{c}$ firms this is not the case. The cash flow/q interaction term is negative and significant for small and high $\bar{c}$ firms, but positive and significant for large and low $\bar{c}$ firms. These differences are all significant at the one percent level in accordance with our earlier predictions and results. Cash flow and Tobin's q have larger (and significantly different) impacts on investment for large/ low $\bar{c}$ firms than for small/ high $\bar{c}$ firms.

In Panel B of Table VI dividend payouts are used as a discriminatory device. Firms that pay little or no dividends are the most likely to be cash-constrained [Fazzari, Hubbard and Petersen, 1988]. On the other hand, high dividend payout firms are less likely to suffer from managerial discretion, since dividend payouts reduce discretionary spending opportunities [Jensen, 1986]. We define "low dividend" firms as having an average dividend payout ratio over the sample period of less than 10 percent of cash flow, and "high dividend" firms as those with an average dividend payout ratio above 10 percent.[26] The sample is again first split only by the dividend criterion (columns 2 and 3 in Panel B of Table VI), and then according to $\bar{c}$. The results again support our prior claims. Low dividend/high $\bar{c}$ firms match the predictions of the asymmetric information hypothesis, low dividend/low $\bar{c}$ firms match the managerial discretion hypothesis.

An additional obvious criterion for splitting the sample, given the logic of our tests of the two hypotheses, is by Tobin's q. The investment of firms with $\bar{c} \geq 1$ <u>and</u> $q < 1$ should be most susceptible to cash constraints problems, managers of companies with $\bar{c} < 1$ <u>and</u> $q > 1$ are most likely to have the discretion to overinvest and to be using it. Such splits greatly reduce the numbers of observations in each subsample, however. Nevertheless, the predictions of the two hypotheses are again confirmed for the two subsamples.[27]

We have stressed the importance for investment models of the distinction between marginal and average (Tobin's) q. We have employed our own measure of marginal q, but for Tobin's q we have chosen one of the many measures others have used, namely firm market value divided by total assets. Although more complicated measures of q may have conceptual advantages for other purposes, we think that this simple measure is well-suited for the role q plays in our model - particularly with respect to the asymmetric information hypothesis. The capital market can readily ascertain the book value of a company's total assets from its balance sheet. If the market value of the firm is much above this balance sheet figure, it is reasonable to assume that the company will not have difficulty in raising capital externally. Nevertheless, we have checked the robustness of our results with respect to other definitions of Tobin's q. Our conclusions do not change if we define q as in Lindenberg and Ross [1981], or in Kaplan and Zingales [1997],[28] or when we adjust the denominator of Tobin's q for the intangible capital stock due to R&D.[29]

IV. Conclusions

Both the asymmetric information and managerial discretion hypotheses predict a positive relationship between companies' cash flows and their investments. The logic underlying these predictions is quite different, however, and this logic leads to the complementary predictions that the returns on investment for firms that fit the asymmetric information hypothesis are *greater* than their costs of capital, while the returns on investment for firms that fit the managerial discretion hypothesis are *less* than their costs of capital. We have used these predictions of the two theories to subdivide our 562 companies into two samples, and tested each hypothesis for the sample for which it was best suited.

Many studies have used Tobin's q to control for differences in investment opportunities across companies. We have argued, however, that because q reflects differences in *average* returns on capital across firms, it is inferior to a measure of *marginal* returns on capital, i.e. returns on investment, to control for investment opportunities. We have calculated such a measure, our c_t, which represents the ratio of the returns on a firm's investment to its cost of capital, and used it to capture differences in investment opportunities across companies.

Although we do not interpret Tobin's *q* as a measure of investment opportunities, we do include it to test both hypotheses. We predict that the sensitivity of investment to cash flow declines under the asymmetric information hypothesis as *q* rises, because firms with high *q*s should have less difficulty raising external capital. In contrast we predict an increase in the coefficient on cash-flows as *q* rises under the managerial discretion hypothesis. Both predictions are supported for the capital investment equation in the appropriate samples of companies, and the prediction is supported for the managerial discretion hypothesis subsample, when R&D is the dependent variable.

We did not observe a negative coefficient for the *q*-cash flow interaction when R&D is the dependent variable, and the asymmetric information hypothesis subsample is used. This result is less damaging to the asymmetric information hypothesis than it may seem. The negative sign on the *q*-cash flow interaction variable is predicted, because cash flow should be less essential for financing attractive investment projects for companies with high Tobin's *q*s. These firms can readily raise the required funds in the equity or bond markets. R&D is a much longer run type of investment than purchases of plant and equipment, however, and adjustments in levels of R&D spending are likely to be slow. Thus, companies are less likely to issue equity and debt to finance R&D, and the importance of cash flow to finance R&D is unaffected by the level of *q*.

We do not predict nor find a relationship between c_{t-1} and investment for firms that fit the managerial discretion hypothesis, since these firms have on average invested in projects with returns below their shareholders' opportunity costs. Only the measures of managerial discretion - cash flow and *q* - explain the investments of these companies.

In contrast, companies which on average have returns on investment greater than their costs of capital are behaving in a way which is consistent with their maximizing shareholder wealth, albeit perhaps under the handicap of asymmetric information. We expect and find that the investments of these companies respond to changes in our measure of returns on investment.

Market ignorance of the returns on a company's capital and investments cannot last forever. Time reveals these returns and asymmetry of information disappears. We thus predict a weakening of support for the asymmetric information hypotheses in our balanced panel of firms as time elapses. This prediction is also confirmed by the data.

There is no analogous logical argument to lead us to predict a decline in managerial discretion over time. Because a wave of hostile takeovers took place in the midst of our sample period, and because many of these appeared to be intended to curb exactly the kinds of abuses of managerial discretion that fit our hypothesis, we tested to see whether there was evidence of a decline in managerial discretion over time. This prediction was also confirmed.

Thus, the results of this article support both of the two main hypotheses tested. For companies that had, on average, marginal returns on investment equal to or greater than their costs of capital, the estimates for both the investment and the R&D equations offered more support for the asymmetric information hypothesis at the beginning of our sample period than at the end. This too can be interpreted as support for the asymmetric information hypothesis, since it is reasonable to assume that the capital market's ignorance of the returns on investment of companies disappears over time. Those companies whose returns on investment over the 1979-96 period were at least equal to their costs of capital were projected by the end of the period to behave fairly closely to the predictions of the neoclassical q-theory with respect to both their R&D and investment -- a strong relationship between q and each type of investment outlay, almost no relationship between cash flow and the two types of investment.

Although our estimates also imply a reduction of managerial discretion over the sample period, they do not imply its total disappearance. Cash flow and q both are projected to have strong independent and a (weak) joint impact on both capital investment and R&D spending. Our estimate of the marginal effect of cash flow on investment for the managerial discretion subsample is more than double that for the asymmetric information subsample; cash flow's marginal effect on R&D is almost five times greater for the managerial-discretion subsample. Tobin's *q* also has much larger marginal impacts on the two investment outlays for the managerial discretion subsample. Although the hostile takeovers of the 1980s may have induced a decline in managers' willingness to exercise the discretion at their disposal, evidence of managerial discretion in the investment behavior of companies has by no means disappeared.

These conclusions are reinforced by several robustness checks using additional splits of the sample such as size and dividend payouts.

UNIVERSITY OF VIENNA, DEPARTMENT OF ECONOMICS, AUSTRIA

REFERENCES

Bond, S. and C. Meghir, "Dynamic Investment Models and the Firm's Financial Policy", *Review of Economic Studies,* LXI (1994), 197-222.

Carpenter, Robert E., "Finance Constraints or Free Cash Flow? A New Look at the Life Cycle Theory of the Firm", *Empirica,* XXII (1995), 185-209.

Duesenberry, J.S., *Business Cycles and Economic Growth*, (New York: MacGraw Hill: 1958)

Economist, Ready to Take on the World, Jan. 15, (1994), 65-66.

Fazzari, S.M. , Hubbard R. G. and Petersen B., "Financing Constraints and Corporate Investment", *Brookings Papers on Economic Activity,* (1988), 141-195.

Grabowski, H. and Dennis. C. Mueller. "Managerial and Stockholder Welfare Models of Firm Expenditures", *Review of Economics and Statistics,* LIV (1972), 9-24.

Grunfeld, Yehuda. "The Determinants of Corporate Investment", in A.C. Harberger, ed., *The Demand for Durable Goods*, (Chicago: 1960), 211-66.

Hayashi, Fumio. 1982. "Tobin's Marginal q and Average q: A Neoclassical Interpretation", *Econometrica,* L (1982), 213-224.

Hoshi, Takeo, Kashyap, A., Scharfstein, D., "Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups", *Quarterly Journal of Economics*, CVI (1991), 33-60.

Jensen, Michael. C., "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers", *American Economic Review,* LXXVI (1986), 323-29.

Jorgenson, Dale. "Capital Theory and Investment Behavior", *American Economic Review Procedings,* LIII (1963), 247-59.

Jorgenson, Dale. "The Theory of Investment Behavior", in R. Ferber (Ed.) *Determinants of Investment Behavior*, (New York: Columbia University Press: 1967).

Kaplan, Steven N. and Luigi Zingales. "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?", *Quarterly Journal of Economics*, CXII (1997), 169 – 215.

Kadapakkam, P.R., P. C. Kumar, and L. A. Riddick. "The Impact of Cash Flows and Firm Size on Investment: The International Evidence", *Journal of Banking and Finance,* XXII (1998), 293-320.

Kathuria, R. and Dennis C. Mueller. "Investment and Cash Flow: Asymmetric Information or Managerial Discretion", *Empirica,* XXII (1995): 211-234.

Lewellen, G. L. and S. G. Badrinath. "On the Measurement of Tobin's q", *Journal of Financial Economics*, XLIV (1997), 77-122.

Lindenberg, E. and S. Ross. "Tobin's q Ratio and Industrial Organization", *Journal of Business,* LIV (1981), 1-33.

Marris, Robin. *Managerial Capitalism in Retrospect*, (London: Macmillan, 1998)

Marris, Robin.1964. *The Economic Theory of Managerial Capitalism*, London: Macmillan, 1964)

Meyer J.R. and Kuh, E., The Investment Decision. (Cambridge, MA: Harvard University Press, 1957).

Modigliani, Franco and M. Miller. "The Cost of Capital, Corporation Finance and The Theory of Investment", *American Economic Review,* XLVIII (1958), 261-97.

Mikkelson Wayne H., Partch M. Megan, "The Decline of Takeovers and Disciplinary Managerial Turnover", *Journal of Financial Economics,* XLIV (1997), 205-228

Mueller, D.C and B.B. Yurtoglu, 1998, "Rate of Return on Corporate Investment: A Cross-National Comparison", ESRC Centre for Business Research, University of Cambridge, WP 108, December.

Mueller, Dennis C., and Reardon, Elizabeth. "Rates of Return on Corporate Investment", *Southern Economic Journal,* LX (1993), 430-53.

Myers, S. C. and N. Majluf N.S. "Corporate Financing and Investment Decisions When Firms Have Information that Investors Do No", *Journal of Financial Economics,* XIII (1984), 187-221.

Nadiri M. I. and I. Prucha, "Estimation of the Depreciation Rate of Physical and R&D Capital in the U.S. Total Manufacturing Sector", *Economic Inquiry,* I (1996), 43-56.

Stiglitz, J. and Andrew Weiss. "Credit Rationing in Markets with Imperfect Information", *American Economic Review*, LXXI (1981), 393-410.

Tobin, James. "A General Equilibrium Approach to Monetary Policy", *Journal of Money, Credit and Banking*, I (1969), 227-240.

Vogt, S.C., "The Cash Flow/Investment Relationship: Evidence from U.S. Manufacturing Firms", *Financial Management,* XXIII (1994), 3-20.

NOTES

1. For a full exposition of the assumptions underlying the *q*-theory, see Hayashi [1982].

2. See, Meyer and Kuh [1957].

3. Myers and Majluf [1984], Fazzari, Hubbard and Petersen [1988]. Hoshi, Kashyap, and Scharfstein [1991].

4. Marris [1964, 1998] first motivated and developed the growth maximization hypothesis. Grabowski and Mueller [1972] were the first to test its implications using a cash flow/investment model. For more recent tests see, Vogt [1994], Carpenter [1995] and Kathuria and Mueller [1995].

5. A third explanation for a positive relationship between investment and cash flow would be that a firm encounters rising transaction costs as it enters the external capital market [Duesenberry, 1958]. This explanation makes similar predictions to the asymmetric information hypothesis, and thus we do not try to test for it separately.

6. Testing for the presence of asymmetric information by forming one subsample of companies that are likely to be cash constrained, and a second with companies that are unlikely to be constrained has become standard practice in the literature. See, Fazzari, Hubbard and Petersen [1988]. We modify this procedure by choosing a different criterion for making the split.

7. Mergers would be an obvious third form of investment to try and explain with the two theories. The extreme "lumpiness" of this investment creates severe estimation problems, however, and thus we do not include it as one of our investment decisions in this paper.

8. See, *Economist* [1994] and Mikkelson and Partch [1997], who report a more active market for corporate control in the period 1984 to 1988 than the 1989-1993 period.

9. See again, Hayashi [1982] for a formal development of the theory.

10. We use this approach to calculate a separate c for each firm for the period 1977-1996 in section E.

11. Mueller and Readon [1993] have estimated δ to be between six and eight percent. Mueller and Yurtoglu [1998] estimate δ to be around five percent for a larger sample of companies from around the world. As a robustness check on this estimate, we repeat all our calculations with δs of five and 10 percent. The qualitative nature of our results is not affected by the choice of δ.

12. Indeed, if all companies with $\bar{c} \geq 1$ had investment opportunities as depicted in Figure 2a, and none could raise any external capital, their investments should exactly equal their cash flows, and the coefficient on cash flow in an investment equation for this subsample would equal 1.0.

13. See Jensen [1986] and references in footnote 4. Kathuria and Mueller [1995] assume that managerial utilities are a function of the growth of the firm and security from takeover, and derive the prediction that *both* investment and dividends increase with increases in cash flows, and thus that the coefficient on cash flow in an investment equation is positive and less than one.

14. The merger wave that has accompanied the booming stockmarket of the late-1990s suggests that the decline in managerial empire-building may have been short lived.

15. We tried a number of other definitions of Tobin's q, see the discussion in section III.

16. We add (*1-tax rate*) times the R&D expenditures to cash flow. The tax rate that is used is 50 percent for the 1979-1987 period and 34 percent for the 1988-1996 period.

17. We have also estimated a separate *c* for each company using a version of equation (7). This procedure allows for the simultaneous estimation of the depreciation rate, δ, and *c*. The correlation coefficient of estimated and calculated cs was about 0.6 and none of our results changed qualitatively. These results are available from the authors upon request.

18. For all variables that enter our equations, the extreme values defined as the top and bottom one percent of the sample observations are deleted. This allows for a uniform definition of outliers and leads to more robust results.

19. Kaplan and Zingales [1997] conclude from 10-K reports and balance sheet data for Fazzari, Hubbard and Petersen's [1988] sample that fewer than a sixth of the companies were cash constrained. Kaplan and Zingales speculate that cash flow may be proxying for investment opportunities for the unconstrained companies. Since this does not appear to be a likely explanation for a positive relationship between cash flow and investment in our sample, we are left with the managerial discretion and asymmetric information hypotheses to explain such a relationship.

20. Throughout the paper all partial derivatives with respect to either CF_{t-1} or q_{t-1} are evaluated at the mean of the other variable in the interaction term. To perform simple t-tests on the difference between coefficients from different samples we have to assume that the regression error terms are independent across sub-samples.

Statistical significance between regression coefficients is indicated by an equality sign between columns 2 and 3.

21. Since the full sample has been partitioned by the values of mean c over the full sample period, the variances of c_{t-1} are reduced in both subsamples. This reduction in variation could bias the coefficients on c_{t-1} towards zero, and may help to explain the insignificance of c_{t-1} in the $\bar{c} < 1$ subsample. The same bias exists in the $\bar{c} \geq 1$ subsample, however, where the coefficient on c_{t-1} was positive and significant as predicted. This result plus the statistical significance of the difference between the coefficients on c_{t-1} for the two subsamples leads us to believe that our partitioning by $\bar{c}$ does not cause serious bias.

22. The sign of the partial derivative of investment with respect to q_{t-1} remains positive for almost all firms according to the distribution of Tobin's q's.

23. At first sight, one may wonder about the negative coefficients for cash flow and Tobin's q in the R&D equation for the $\bar{c} < 1$ firms. However, the cash flow/q interaction term more than outweighs these negative direct effects of cash flow and q so that the predicted marginal effects of both cash flow and q (evaluated at the respective sample means) are positive and significant.

24. See e.g. Vogt [1994], Bond and Meghir [1994] and Kadapakkam et al. [1998].

25. he results for small and $\bar{c} < 1$ firms and for large and $\bar{c} \geq 1$ firms lie in between the two "extreme" subsamples and are available from the authors upon request.

26. This is comparable to what Fazzari, Hubbard and Petersen [1988] do.

27. Results available from the authors upon request.

28. The most controversial part of Tobin's q is the replacement cost of the firm's fixed assets [see e.g. Lewellen and Badrinath, 1997]. We experimented with a number of different definitions for Tobin's q and obtained the following results [detailed results are available upon request]. (1) When we define Tobin's q in spirit of Kaplan and Zingales [1997] [Tobin's q = [market value of the firm plus total assets minus book value of common equity minus balance sheet deferred taxes / total assets], all of our results carry over, some are even more pronounced. (2) When we define Tobin's q in the spirit of Lindenberg and Ross [1981] (Tobin's q = (market value of the firm) / (total assets plus replacement cost of fixed assets minus book value of fixed assets plus LIFO reserve plus total debt minus total liabilities), all results carry over qualitatively although there is some reduction in significance.

29. We thank Bruce Petersen for suggesting this test. We estimated R&D capital as R&D spending times 5 or times 10 assuming that the firm is in a steady state and the R&D stock depreciates at a constant 20 percent or 10 percent rate. These rates are consistent with the range of depreciation rates presented in the literature [Nadiri and Prucha, 1996]. With Tobin's q defined as the ratio of the market value to total assets plus this R&D stock, marginal q remains much more important for the $\bar{c} \geq 1$ firms compared to $\bar{c} < 1$ firms, and the reverse is true for average q. The cash flow / q interaction term is negative for the $\bar{c} \geq 1$ subsample and positive for the $\bar{c} < 1$ subsample, however, the difference is now not significant at conventional level.

Table I

Predicted Signs of Coefficients from the Different Theories

Theory	Neoclassical/ q-theory		Asymmetric Information		Managerial Discretion	
Sample	(All firms)		(Firms with $\bar{c} \geq 1$)		(Firms with $\bar{c} < 1$)	
Dependent Variable	I_t/K_{t-1}	R_t/K_{t-1}	I_t/K_{t-1}	R_t/K_{t-1}	I_t/K_{t-1}	R_t/K_{t-1}
Independent Variables:						
Intercept	+	+	+	+	+	+
CF_{t-1}/K_{t-1}	0	0	+	+	+	+
c_{t-1}	NA	NA	+	?	?	?
q_{t-1}	+	+	+	+	+	+
$q_{t-1} \cdot CF_{t-1}/K_{t-1}$	0	0	-	-	+	+

$\bar{c}$ is the calculated sample period marginal q
CF_{t-1}/K_{t-1} is cash flow divided by the book value of capital stock lagged one period
c_{t-1} is our yearly measure of marginal q lagged one period
q_{t-1} is Tobin's q lagged one period
$q_{t-1}\ CF_{t-1}/K_{t-1}$ is an interaction term of Tobin's q and cash flow
NA = not applicable. Under the neoclassical theory c should equal q and only one variable enters the equation.

Table II

Summary Statistics and Correlation Matrix

Panel A. Summary Statistics

	All			$\bar{c} < 1$			$\bar{c} \geq 1$		
Variables:	Mean	Med	S.D.	Mean	Med	S.D.	Mean	Med	S.D.
Sales (Mill $)	2750.1	356.9	8648	3266	309.8	9416.0	1965.2	408.5	7258
DSAL	0.04	0.03	0.23	0.02	0.01	0.17	0.07	0.05	0.31
Div. Payout Ratio	0.24	0.20	0.64	0.24	0.19	0.80	0.24	0.22	0.27
I_t/K_{t-1}	0.27	0.22	0.23	0.26	0.21	0.21	0.30	0.24	0.26
R_t/K_{t-1}	0.157	0.085	0.229	0.163	0.09	0.24	0.147	0.079	0.212
q_t	1.15	0.96	0.69	0.95	0.85	0.44	1.46	1.23	0.87
c_t	1.05	0.89	2.72	0.82	0.72	2.57	1.39	1.19	2.90
CF_t/K_t	0.35	0.31	0.43	0.35	0.29	0.43	0.36	0.33	0.44
Number of Firms		562			328			234	
Number of Obs.		7513			4534			2979	

Panel B. Matrix of Correlation Coefficients: All firms

	$\bar{c}$	q_t	I_t/K_{t-1}	R_t/K_{t-1}	CF_t/K_t	DSAL	Sales	c_t
$\bar{c}$	1.0							
q_t	0.432	1.0						
I_t/K_{t-1}	0.026	0.177	1.0					
R_t/K_{t-1}	-0.015	0.220	0.339	1.0				
CF_t/K_t	0.019	0.183	0.330	0.507	1.0			
DSAL	0.080	0.142	0.344	0.172	0.136	1.0		
Sales	-0.064	-0.086	-0.032	-0.078	-0.063	-0.012	1.0	
c_t	0.116	0.301	0.101	0.036	0.060	0.122	-0.014	1.0

$\bar{c}$ is the calculated sample period marginal q
Sales is average total annual sales,
DSAL is average annual growth rate of total sales
Div. payout ratio is the average of total dividends paid over the sample period divided by total cash flows over the sample period
I_t/K_{t-1} is capital investment divided by the beginning of period book value of capital stock
R_t/K_{t-1} is expenditures of research and development divided by the beginning of period book value of capital stock
q_t is Tobin's q calculated as the market value of equity plus the value of debt divided by total assets
c_t is the yearly measure of marginal q
CF_t/K_t is cash flow (income before extraordinary items plus depreciation minus dividends plus (1 - *tax rate*) times R&D expenditures) divided by the beginning of period book value of capital stock

Table III
Regression results

Panel A: OLS regression results with I/K as dependent variable

Equation	1		2			3		4		5		6	
Sample	All		$\bar{c} \geq 1$			$\bar{c} < 1$		All		$\bar{c} \geq 1$		$\bar{c} < 1$	
	Coef	t-val	Coef	t-val		Coef	t-val	Coef	t-val	Coef	t-val	Coef	t-val
CF_{t-1}/K_{t-1}	0.160	16.29	0.190	10.88	≈	0.089	6.82	0.146	14.85	0.093	4.48	0.149	8.66
c_{t-1}	0.005	5.10	0.008	4.67	>	0.002	1.44	0.005	4.86	0.008	4.57	0.002	1.57
q_{t-1}	0.052	11.19	0.039	5.69	<	0.068	7.68	0.060	10.61	0.036	5.27	0.079	8.93
$q_{t-1}*CF_{t-1}/K_{t-1}$	-0.018	-3.55	-0.039	-5.34	<	0.040	4.26	-0.045	-8.15	-0.028	-3.79	-0.030	-2.34
$1/t*CF_{t-1}/K_{t-1}$								—	—	0.339	8.44	-0.100	-2.54
$1/t*c_{t-1}$								—	—	—	—	—	—
$1/t*q_{t-1}$								-0.062	-3.00	—	—	—	—
$1/t*q_{t-1}*CF_{t-1}/K_{t-1}$								0.158	12.80	—	—	0.147	7.02
Firms	562		234			328		562		234		328	
No. Obs.	7513		2979			4534		7513		2979		4534	
R^2	0.16		0.12			0.18		0.18		0.14		0.23	

Panel B: OLS regression results with R/K as dependent variable

Equation	1		2			3		4		5		6	
Sample	All		$\bar{c} \geq 1$			$\bar{c} < 1$		All		$\bar{c} \geq 1$		$\bar{c} < 1$	
	Coef	t-val	Coef	t-val		Coef	t-val	Coef	t-val	Coef	t-val	Coef	t-val
CF_{t-1}/K_{t-1}	0.220	25.54	0.134	10.55	<	0.187	14.29	0.204	23.81	0.033	2.27	0.230	13.24
q_{t-1}	0.032	7.93	0.040	8.47	≈	0.014	1.66	0.045	9.13	0.037	7.88	0.063	5.59
q_{t-1} CF_{t-1}/K_{t-1}	0.004	0.91	0.001	0.25	<	0.083	8.74	-0.025	-5.09	0.013	2.44	0.014	1.06
1/t CF_{t-1}/K_{t-1}								—	—	0.350	12.14	-0.074	-1.70
1/t q_{t-1}								-0.097	-5.34	—	—	-0.197	-5.49
1/t q_{t-1} CF_{t-1}/K_{t-1}								0.177	16.41	—	—	0.186	6.81
Firms	562		234			328		562		234		328	
No. Obs.	7513		2979			4534		7513		2979		4534	
R^2	0.35		0.31			0.42		0.38		0.35		0.44	

Note: <, >, ≈ means significantly smaller, larger or not significantly different, respectively. The q/cash flow interaction term is evaluated at the subsample means, when we test for the impacts of cash flow and Tobin's q. All regressions include 2-digit industry and year dummies. 1/t· are interaction terms with the reciprocal of time, 1/t. For the other variable definitions see tables I and II.

Table IV

Predicted Partial Derivatives Derived From Table III

Panel A: Dependent variable I/K

	Whole Period (see Eq 1,2, and 3)			1979 (Eq 4, 5, and 6 with *t = 1*)			Long run (Eq 4, 5, and 6 with $t \to \infty$)		
	All	$\bar{c} \geq 1$	$\bar{c} < 1$	All	$\bar{c} \geq 1$	$\bar{c} < 1$	All	$\bar{c} \geq 1$	$\bar{c} < 1$
CF_{t-1}/K_{t-1}	0.16 - 0.018q	0.19 - 0.039q	0.089 + 0.04q	0.146 + 0.113q	0.433 - 0.028q	0.046 + 0.117q	0.146 - 0.045q	0.093 - 0.028q	0.149 - 0.03q
Evaluated at mean	0.139*	0.134*	0.129*	0.256*	0.402*	0.152*	0.094*	0.053*	0.120*
q_{t-1}	0.052 - 0.018CF	0.039 - 0.039CF	0.068 + 0.04CF	-0.002 + 0.113CF	0.036 - 0.028CF	0.079 + 0.117CF	0.06 - 0.045CF	0.036 - 0.028CF	0.079 - 0.03CF
Evaluated at mean	0.046*	0.025*	0.082*	0.074*	0.017*	0.159*	0.045*	0.025*	0.069*

Panel B: Dependent variable R/K

	Whole Period (see Eq 1,2, and 3)			1979 (Eq 4, 5, and 6 with *t = 1*)			Long run (Eq 4, 5, and 6 with $t \to \infty$)		
	All	$\bar{c} \geq 1$	$\bar{c} < 1$	All	$\bar{c} \geq 1$	$\bar{c} < 1$	All	$\bar{c} \geq 1$	$\bar{c} < 1$
CF_{t-1}/K_{t-1}	0.22+0.004q	0.134+0.001q	0.187 + 0.083q	0.204 + 0.152q	0.384 + 0.013q	0.156 + 0.20q	0.204 - 0.025q	0.033 + 0.013q	0.23 + 0.014q
Evaluated at mean	0.22*	0.137*	0.266*	0.353*	0.40*	0.337*	0.175*	0.053*	0.243*
q_{t-1}	0.032+0.004CF	0.04+0.001CF	0.014 + 0.083CF	-0.052 + 0.15CF	0.037 + 0.013CF	-0.134 + 0.20CF	0.045 - 0.025CF	0.037 + 0.013CF	0.063 + 0.014CF
Evaluated at mean	0.032*	0.04*	0.043*	0.05*	0.042*	0.002	0.036*	0.042*	0.067*

Note: q and CF denote q_{t-1} and CF_{t-1}/K_{t-1}, respectively. All interaction terms are evaluated at the respective sample means for the relevant variables.
* Significant at the one percent level

Table V

Robustness I: Different Specifications and Fixed Effects

	OLS				Fixed Effects							
	I/K								R/K			
Sample	All	$\bar{c} \geq 1$		$\bar{c} < 1$	All	$\bar{c} \geq 1$		$\bar{c} < 1$	All	$\bar{c} \geq 1$		$\bar{c} < 1$
Accelerator	0.062	0.082	>	0.047	—	—		—	—	—		—
t-value	28.52	20.50		18.88	—	—		—	—	—		—
CF_{t-1}/K_{t-1}	0.126	0.122	≈	0.081	0.161	0.188	<	0.099	0.076	0.074	≈	-0.009
t-value	13.40	7.26		6.42	14.72	9.65		6.88	11.83	6.93		-1.07
c_{t-1}	0.003	0.004	≈	0.001	0.005	0.008	>	0.003	—	—		—
t-value	3.34	2.73		0.75	5.43	4.59		2.30	—	—		—
q_{t-1}	0.038	0.024	<	0.057	0.060	0.048	<	0.077	0.024	0.041	≈	-0.039
t-value	8.39	3.69		6.67	9.40	5.20		7.34	6.62	8.48		-6.29
$q_{t-1}\ CF_{t-1}/K_{t-1}$	-0.007	-0.015	<	0.037	-0.016	-0.037	<	0.036	0.028	0.003	<	0.125
t-value	-1.48	-2.12		4.05	-2.80	-4.48		3.66	8.11	0.61		20.55
Firms	562	234		328	568	234		328	568	234		328
No. Obs.	7513	2979		4534	7513	2979		4534	7513	2979		4534
R^2	0.24	0.23		0.27	0.23	0.17		0.30	0.75	0.62		0.78

Note: <, >, ≈ means significantly smaller, larger or not significantly different, respectively, where the q/cash flow interaction term is evaluated at the subsample means when we test for the impacts of cash flow and Tobin's q. Accelerator is lagged difference in sales divided by the capital stock. All other variables are defined in tables I and II.

Table VI

Robustness II: Alternative splits, the dependent variable is I/K

Panel A: Splits according to firm size as measured by annual total sales

Sample	All			$\bar{c} \geq 1$		$\bar{c} < 1$
	Small		Large	Small		Large
CF_{t-1}/K_{t-1}	0.16	≈	0.21	0.17	≈	0.12
t-value	12.38		7.71	7.71		3.62
c_{t-1}	0.0092	>	0.004	0.012	>	0.0018
t-value	5.46		2.93	3.85		1.04
q_{t-1}	0.059	>	0.020	0.043	≈	0.030
t-value	8.49		2.15	4.23		2.11
$q_{t-1}*CF_{t-1}/K_{t-1}$	-0.022	<	0.015	-0.038	<	0.090
t-value	-3.37		0.73	-4.13		3.15
No. Obs.	3756		3757	1363		2144
R^2	0.15		0.21	0.11		0.31
Predicted partial derivatives (evaluated at respective means):						
CF_{t-1}/K_{t-1}	0.133	<	0.23	0.12	<	0.21
t-value	15.61		16.27	8.05		13.38
q_{t-1}	0.05	>	0.025	0.027	<	0.055
t-value	8.14		4.52	2.93		5.87

Small: Annual sales < median sales; Large: Annual sales > median sales.

Panel B: Splits according to dividend payout policy

Sample	All			$\bar{c} \geq 1$		$\bar{c} < 1$
	Low Dividends		High Dividends	Low Dividends		Low Dividends
CF_{t-1}/K_{t-1}	0.21	>	0.12	0.19	≈	0.15
t-value	10.06		7.44	5.27		4.89
c_{t-1}	0.0132	>	0.0054	0.018*	>	0.0068
t-value	4.85		5.03	4.00		1.78
q_{t-1}	0.067	>	0.027	0.043	<	0.088
t-value	6.67		4.08	3.29		3.82
$q_{t-1}*CF_{t-1}/K_{t-1}$	-0.036	<	0.002	-0.043	<	0.026
t-value	-4.22		0.19	-3.83		1.29
No. Firms	149		413	60		89
No. Obs.	1831		5661	733		1098
R^2	0.17		0.13	0.11		0.24
Predicted partial derivatives (evaluated at respective means):						
CF_{t-1}/K_{t-1}	0.16	>	0.12	0.11	<	0.17
t-value	11.45		15.48	4.96		10.27
q_{t-1}	0.05	>	0.027	0.023	<	0.10
t-value	5.51		6.05	1.90		5.61

Low dividends: Average firm dividend payout ratio over sample period < 10 percent of cash flows; High dividends: Average firm dividend payout ratio over sample period > 10 percent of cash flows.

Note: <, >, ≈ means significantly smaller, larger or not significantly different, respectively.

Figure I

Identical Optimal Investments with Different Returns on Capital

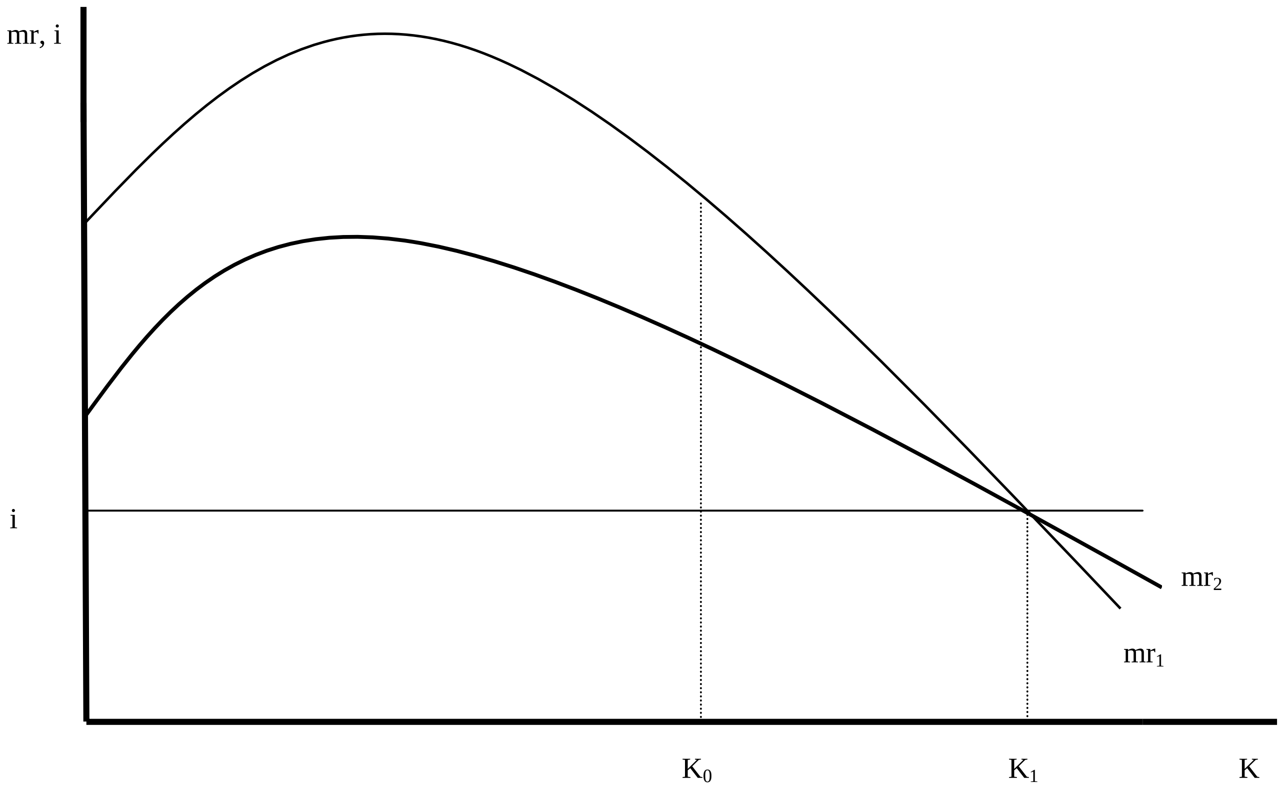

Figure II
Investments with c ≥ 1 and c< 1