

# MARGINAL $q$ , TOBIN'S $q$ , CASH FLOW AND INVESTMENT\*

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## 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 560 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

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Cash flow has always been somewhat of a puzzle in the literature on the determinants of investment. In a strictly neoclassical world, cash flow does not belong in an investment equation, and yet empirical studies dating back over 40 years almost invariably find that cash flow and investment are positively related.<sup>1</sup> A variety of hypotheses have been put forward to account for this empirical regularity including the existence of transaction costs, agency problems and asymmetric information.<sup>2</sup> This paper provides tests of the latter two hypotheses using a sample of 560 U.S. companies over the period 1977 to 1996.

Under the asymmetric information (hereafter AI) hypothesis firms with attractive investment opportunities may be unable to finance them because of inadequate internal cash flows, and because the cost of external funds is too high due to the capital market's ignorance of the firm's investment opportunities.<sup>3</sup> Thus, only firms with large cash flows can finance their attractive investment opportunities, and the puzzle of the relationship between cash flow and investment is resolved. To test this hypothesis, we need to identify those firms that may be subject to AI problems. The very nature of AI makes it difficult if not impossible to cleanly identify firms in this situation. If a researcher can identify a firm with attractive investment opportunities and cash constraints, why can the market not do so? Previous studies have used size, level of dividends, age, concentration of share ownership and extent of cross-shareholdings to identify firms that are *possibly* subject to AI problems.<sup>4</sup> Although the capital market may have difficulty judging the investment opportunities of small firms, this in itself need not imply that the firm has attractive investment opportunities or that its cash flows are inadequate to finance them, if it does. Similar criticisms can be lodged against the other characteristics used to identify firms subject to AI problems.<sup>5</sup> One of this article's contributions is to use a characteristic of firms that better identifies whether they suffer from AI problems.

The AI hypothesis assumes that the firm's managers seek to maximize their shareholders'

wealth, but are prevented by a shortage of cash from undertaking investments with expected returns above the firm's cost of capital. Any firm caught in this predicament should, therefore, have a return on its investment,  $r$ , that is greater than its cost of capital,  $i$ . Our procedure for identifying firms subject to such cash constraints is thus to estimate the ratio  $r/i$  for each firm over our sample period, and to categorize any firm for which this  $r/i > 1$ , as possibly cash constrained.<sup>6</sup>

The agency hypothesis links investment to cash flows by assuming that managers obtain financial and psychological gains from managing a large and growing firm and thus invest beyond the point that maximizes shareholder wealth.<sup>7</sup> When this occurs, a company's returns on investment will be *less* than its cost of capital. Accordingly we identify firms for which  $r/i < 1$ , as possibly subject to agency or managerial discretion (hereafter MD) problems.

Both the AI and MD hypotheses treat cash flow as a measure of financial constraints. It is possible, however, that current cash flows merely proxy for the profitability of future sales. Thus, in testing for the importance of cash flows as a source of capital it is necessary to control for the investment opportunities of firms (Chirinko and Schaller, 1995, p. 528). Many studies have used Tobin's  $q$  as such a control. Tobin's  $q$  reflects the *average* return on a company's capital, but what is relevant for investment is the *marginal* return on capital. What is needed, therefore, is an estimate of marginal  $q$ . The existing literature has continued to use measures of average  $q$ , even though the conditions under which it equals marginal  $q$  are quite stringent (e.g., constant returns to scale, perfect competition in all product markets).<sup>8</sup> When firms operate in imperfectly competitive markets, some earn rents and these rents are capitalized in their market values. Differences in average  $qs$  may be dominated by differences in *inframarginal* returns on capital, and thus may be poor predictors of investment. An important contribution of this paper is to replace Tobin's average  $q$  as a control for the investment opportunities of firms with the

theoretically appropriate marginal  $q$ .<sup>9</sup> Throughout the paper we use  $qa$  to represent average  $q$  and  $qm$  to represent marginal  $q$ .

Although  $qa$  is likely to be a poor proxy for the investment opportunities of a company, it can be a good indicator of the presence of asymmetric information for firms with  $r$  greater than  $i$ . The higher  $qa$  is, the cheaper it should be for firms to raise funds by, say, issuing equity, and thus the less important cash flow should be as a constraint on investment. We thus predict for firms that are likely to suffer from AI problems that their investment is less responsive to cash flow differences, the higher their  $qas$  are.

Tobin's  $q$  also figures in our tests of the MD hypothesis. The chief constraint on managers' exercising their discretion over the allocation of a firm's cash flows is the threat of a takeover and dismissal should the firm's share price fall too low. The higher the firm's share price is, therefore, the greater the freedom managers have to overinvest. We thus predict for the sample of firms that is likely to suffer from agency problems that their investment is more responsive to cash flow differences, the higher their Tobin's  $qs$  are.

We thus see the three main contributions of this paper as being: First, to estimate a marginal  $q$  and use it to separate the population of firms into those which are likely to fit the AI and MD hypotheses. Second, to use marginal  $q$  to control for investment opportunities so that cash flows' effect is limited to its role as a source of liquidity. Third, to use  $qa$  not as a control for investment opportunities as in other studies, but as a measure of the cost of external finance for firms potentially subject to cash flow constraints, and as a measure of the tightness of the takeover constraint for firms potentially suffering from agency problems. As already stressed, our use of both marginal and average  $q$  is new to the literature. Only Kathuria and Mueller (1995) have estimated a marginal  $q$  and used it to separate firms into different subsamples as we do. They did not employ marginal  $q$  to control for the investment opportunities of the firm,

however, nor did they use Tobin's  $q$  in the way we do to discriminate between the two hypotheses.

A fourth contribution of the paper will be to see whether the merger wave of the late 1980s, which included many hostile takeovers, tightened the takeover constraint on managers, and led to 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 late 1980s and 1990s.<sup>10</sup> We find no evidence in support of this hypothesis, however.

We proceed as follows. Section I reviews various theoretical arguments for including  $qa$  and cash flow in an investment equation. In it we also explain the methodology for calculating 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 Calculation of Marginal $q$**

The arguments for putting Tobin's  $q$  in an investment equation rest on the assumptions of perfect competition, constant-returns-to-scale and that firms are price takers, which imply that the marginal and average returns on capital are equal, and equal a firm's cost of capital.<sup>11</sup> 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 same level of investment may be optimal for a monopolist as for a competitive firm even though the monopolist's profits on existing

assets, and hence  $qa$ , are much larger than for the competitive firm. To predict the investments of these two companies more accurately, we need a measure of their *marginal* returns on capital relative to their costs of capital, which we now derive.<sup>12</sup>

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 cost of capital in  $t$ , then the present value of this investment is

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

We shall assume capital market efficiency and, thus, that the capital market makes an unbiased estimate of the present value,  $PV_t$ , of any investment,  $I_t$  in  $t$ . We can then take the market's estimate of  $PV_t$  and the investment  $I_t$  that created it, and calculate the ratio of a pseudo-permanent return  $r_t$  on  $I_t$  to  $i_t$ .

$$(2) \quad PV_t = \frac{I_t r_t}{i_t} = qm_t I_t$$

If the firm had invested the same amount  $I_t$  in a project that produced a permanent return  $r_t$ , this project would have yielded the exact same present value as the one actually undertaken. The ratio of  $r_t$  to  $i_t$  is the key statistic in our analysis. If a firm maximizes shareholder wealth, then it undertakes no investments for which  $qm_t < 1$ . That  $qm$  is a marginal  $q$  can easily be seen from (2) by contrasting it with  $qa$ . Average  $q$  is the market value of a firm divided by its capital stock. *Marginal  $q$*  is the *change* in the market value of the firm,  $PV_t$ , divided by the change in its capital stock ( $I_t$ ) that caused it.

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

$$(3) \quad M_t \equiv M_{t-1} + PV_t - \delta_t M_{t-1} + \mu_t$$

where  $\delta_t$  is the depreciation rate for the firm's total capital, and  $\mu_t$  the market's error in evaluating  $M_t$ . Substituting from (2) into (3) and rearranging yields

$$(4) \quad M_t - M_{t-1} = qm_t I_t - \delta_t M_{t-1} + \mu_t$$

The assumption of capital market efficiency implies that the expected value of  $\mu_t$  is zero. Setting  $\mu_t = 0$  and rearranging (4) yields

$$(5) \quad qm_t = \frac{M_t - (1 - \delta)M_{t-1}}{I_t}$$

Eqs. (4) and (5) illustrate the logic underlying our calculation of  $qm$ . Assume, for example, that a firm's cost of capital,  $i_t$ , is 0.10,  $\delta_t = 0$ , and it invests 100 at a return  $r_t = 0.12$ . The predicted increase in its market value using (4) is then 120, and  $qm_t = r_t / i_t = 1.2$ . More generally, a firm's market value rises by more than the amount invested whenever  $r_t > i_t$ , and falls short of the value of  $I_t$  when  $r_t < i_t$ , abstracting from depreciation. Imagine now that  $M_{t-1} = 1000$  and  $\delta_t = 0.10$ . Then the firm must invest 100 at an  $r_t = i_t$  for its market value to remain unchanged.

It should be noted that because we calculate the *ratio* of  $r_t$  to  $i_t$  and not  $r_t$  alone, there is no need to calculate a firm's cost of capital to determine whether it is over- or underinvesting. Moreover, the methodology automatically allows for differences in risk across firms. If firm *A*'s investments involve greater risk than *B*'s, it has a higher cost of capital  $i_t$  than *B*. Any investment  $I_t$  by *A* must then produce a greater expected stream of profits (possess a higher  $r_t$ ) than the equivalent investment by *B* to produce the same change in market value.

Eqs. (3), (4) and (5) 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  $qm_t$ , one needs an estimate of the depreciation rate of a firm's total capital,  $\delta_t$ , 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, and these will differ across industries. If we assume that industry depreciation rates are constant over time, a variant of eq. (4) can be used to estimate a separate  $\delta_D$  for each industry  $D$ .

In eq. (4) it is assumed that the market makes an unbiased estimate of the value of a firm's assets at the end of year  $t-1$ ,  $M_{t-1}$ , and that the change in market value during year  $t$  is due solely to the depreciation of its existing assets, the investment made in  $t$ , and the random error. However, some random shock, like say the Gulf War, might systematically raise or lower the market's valuation of the existing assets of all firms in an industry or sector of the economy. To allow for this possibility, we shall also estimate an industry-specific time shock,  $\sigma_{Dt}$ , for each industry and year. Adding this to eq. (4), rearranging and dividing by  $M_{t-1}$  to correct for heteroscedasticity, we obtain

$$(6) \quad \frac{M_t - M_{t-1}}{M_{t-1}} = -\delta_D + \sigma_{Dt} + qm_t \frac{I_t}{M_{t-1}} + \frac{\mu_t}{M_{t-1}}$$

Imposing the condition that the  $qm_t$  are the same over time and across firms, (6) can be used to estimate  $\delta_D$  and  $\sigma_{Dt}$  with our panel data set. Using these estimates, we can modify eq. (5) to calculate a marginal  $q$  for each firm and each year allowing for both industry differences in depreciation rates and industry-specific time shocks.

$$(7) \quad qm_t = \frac{M_t - (1 - \delta_D + \sigma_{Dt})M_{t-1}}{I_t}$$

Two additional points are worth noting with respect to our calculations of marginal  $qs$ . Although it is conceptually useful to separate industry depreciation rates from industry shocks, some shocks may change the rate of depreciation for all firms in an industry. Thus, eqs. (6) and (7) effectively allow industry depreciation rates to vary over time. Second, a given shock may have the same impact on several industries implying that the  $\sigma_{Dt}$  for these industries are the same.



Eq. (5) defines  $qm$  in year  $t$ . For the purpose of classifying firms into subsamples that fit each hypothesis, we shall calculate a weighted average  $qm$ . Using (3) to replace the first right hand term in successive periods, and assuming again industry specific depreciation rates and industry specific time shocks yields a generalized, multi-period version of (3),

$$(8) \quad M_{t+n} = M_{t-1} + \sum_{j=0}^n PV_{t+j} - \sum_{j=0}^n \delta_{D_{t+j}} M_{t+j-1} + \sum_{j=0}^n \sigma_{D_{t+j}} M_{t+j-1} + \sum_{j=0}^n \mu_{t+j}$$

Using equation (2), we can calculate a weighted average  $qm$  with each year's investment as weights

$$(9) \quad \overline{qm} = \frac{\sum_{j=0}^n qm_{t+j} I_{t+j}}{\sum_{j=0}^n I_{t+j}} = \frac{\sum_{j=0}^n PV_{t+j}}{\sum_{j=0}^n I_{t+j}}$$

Dividing (8) by  $\sum_{j=0}^n I_{t+j}$ , substituting from (9) and rearranging yields

$$(10) \quad \overline{qm} = \frac{M_{t+n} - M_{t-1}}{\sum_{j=0}^n I_{t+j}} + \frac{\sum_{j=0}^n \delta_{D_{t+j}} M_{t+j-1}}{\sum_{j=0}^n I_{t+j}} - \frac{\sum_{j=0}^n \sigma_{D_{t+j}} M_{t+j-1}}{\sum_{j=0}^n I_{t+j}} - \frac{\sum_{j=0}^n \mu_{t+j}}{\sum_{j=0}^n I_{t+j}}$$

Stock market efficiency implies  $E(\mu_{t+j})=0$  for all  $j$ , and thus that the last term on the right in (10) becomes small relative to the other two terms as  $n$  grows large. The market values and investments of the firm are observable. Therefore,  $\overline{qm}$  can be calculated to a close approximation using (10) for any assumed set of  $\delta_{D_t}$ s and  $\sigma_{D_t}$ s when  $n$  is large. We make these calculations using our estimates of  $\delta_{D_t}$  and  $\sigma_{D_t}$  from eq. (6). This  $\overline{qm}$ , the weighted average of the ratio of returns on investment to the cost of capital, is used to discriminate between the different hypotheses regarding investment behavior.

Before describing how we use estimates of  $\overline{qm}$  to test the different hypotheses about investment determinants, we must point out a possible bias in these estimates. We assume that

the capital market at time  $t$  correctly values a firm's existing assets at that time and that the change in its market value between  $t$  and  $t + 1$  reflects the combined effects of the depreciation of its existing assets and the investments made in that period. It is also possible, however, that the market can anticipate future investments. If, for example, the market correctly anticipates at  $t - 1$  the stream of investments  $I_{t+j}$ ,  $j = 1, \dots, n$  and the return  $r$  on these investments, then  $M_{t-1}$  will be higher (lower) than we assume in equation (10), if  $r > i$  ( $r < i$ ). Our calculated  $\overline{qm}$  s are thus biased toward 1.0 to the extent that the market can predict returns on future investments. Nevertheless, as we shall see, we estimate substantial differences in  $\overline{qm}$  s across firms, and they seem to perform as our hypotheses predict.<sup>13</sup>

## **B. 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 1 (a) would invest  $I_0$ . Since this exceeds its internal cash flows,  $CF$ , it would raise the difference between  $I_0$  and  $CF$  on the external capital market. A firm with marginal returns,  $mr_1$ , in Figure 1 (b) would again invest  $I_0$ . Since this falls short of its internal cash flows,  $CF$ , this firm would either pay the difference between  $I_0$  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 do not necessarily hold when the kind of AI 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

$\overline{qm} > 1$ . 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  $\overline{qm} \geq 1$  is, therefore, that their investment should be positively associated with their cash flows.<sup>14</sup>

The greater the difference between  $mr$  and  $i$ , the greater the firm's incentive to raise capital externally, even when its cost of external finance exceeds  $i$ . Thus, our second prediction for firms with  $\overline{qm} \geq 1$  is that their investment in year  $t$  should be positively associated with  $qm_t$ .

Under the AI 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  $\overline{qm} \geq 1$  are subject to AI problems, we also expect a positive correlation between  $qa$  and investment. The reason for this expected positive association is *not* because  $qa$  accurately measures investment opportunities as assumed in the  $q$ -theory, however, in our model  $qm$  plays that role. Instead, a positive relationship between  $qa$  and investment for firms with  $\overline{qm} \geq 1$  is expected, because the ease with which they can raise capital externally should vary directly with  $qa$ . By the same logic firms with high  $qas$  should be less dependent on internal fund flows to finance their investments. We test this implication of the asymmetric information hypothesis by including an interaction term between  $qa$  and cash flow in the investment equation. The predicted sign on this interaction term is negative. The higher  $qa$  is, the weaker is the predicted relationship between cash flow and investment for firms with  $\overline{qm} \geq 1$ .<sup>15</sup>

The reader might be concerned that we have assumed capital market efficiency in estimating individual  $qm_t$  and their weighted average,  $\overline{qm}$ , 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 AI problems based on their weighted average return on investment over the 18 years in our panel data. Our procedure for calculating this average  $qm$  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  $\overline{qm}$  would still be an accurate measure of its average  $qm_t$ , if the market corrected its mistake in a later period.

### **C. The Determinants of Investment with Managerial Discretion**

When  $\overline{qm} < 1$  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.

MD 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. 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 1 (b). Our first prediction for firms with  $\overline{qm} < 1$  is thus that their investments are positively related to their cash flows.<sup>16</sup>

If all firms had the same cost of capital and marginal returns on investment schedule, say  $i$  and  $mr_2$  in Figure 1 (b),  $mr$  would vary inversely with investment, and we would predict a *negative* relationship between  $qm$  and investment for the subsample of companies with  $\overline{qm} < 1$ . 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 may be no relationship between  $qm$  and investment. For example, if firms 1 and 2 in Figure 1 (b) had the same  $i$  and invested amounts  $I_1$  and  $I_2$ , respectively, their  $qms$  would be identical ( $qm = j/i$ ), although their investments would differ. We predict, therefore, that  $qm_t$  and  $I_t$  are unrelated in the subsample of firms for which  $\overline{qm} < 1$ .

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  $qa$  for companies with  $\overline{qm} < 1$ . Since MD manifests itself as overinvestment out of cash flows, the relationship between cash flow and investment should grow *stronger* as MD increases. We thus again include an interaction term between  $qa$  and cash flow in the investment equation, as we did for firms with  $\overline{qm} \geq 1$ . For firms with  $\overline{qm} < 1$ , however, the predicted coefficient on this interaction term is positive, the opposite sign from that predicted under the AI hypothesis. Although the MD hypothesis claims that managers favor internal cash flows as a source of funds, it does not preclude their resorting to the external capital market. Their willingness to do so is likely to be positively related to  $qa$ , and thus we also include it as a separate term in this investment equation.

#### D. Summary of Hypotheses

The basic logic of the two hypotheses applies equally well to investments in capital equipment and in  $R\&D$ , and so we estimate separate equations for each

$$(11) \quad \frac{I_t}{K_{t-1}} = a + b \cdot qm_{t-1} + c \cdot \frac{CF_t}{K_{t-1}} + d \cdot qa_{t-1} + e \cdot \frac{CF_t \cdot qa_{t-1}}{K_{t-1}} + \mu_t^I$$

$$(12) \quad \frac{R_t}{K_{t-1}} = f + g \cdot \frac{CF_t}{K_{t-1}} + h \cdot qa_{t-1} + l \cdot \frac{CF_t \cdot qa_{t-1}}{K_{t-1}} + \mu_t^R$$

where  $I_t$  and  $R_t$  are capital investment and  $R\&D$  in year  $t$ . These equations resemble the reduced-form equations that have been used to test either the AI or the MD hypotheses in other studies. They differ from them, however, in that the investment equation includes the theoretically-preferred *marginal*  $q$  to control for differences in investment opportunities across firms, and average  $q$  enters *not* as a measure of investment opportunities as in other studies, but as an index of either capital market constraints on managers, or market-for-corporate-control constraints. Eqs. (11) and (12) also differ from those usually estimated in the inclusion of an interaction term between cash flow and  $qa$  to take account of the varying intensities of the constraints on managers with respect to the use of cash flows to finance investment. All of the independent variables except for cash flow are lagged one period to avoid their being partly endogenous.<sup>17</sup>

We have classified firms for the purpose of testing the different hypotheses using  $qm$  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  $qm$ , namely the change in a company's market value from the previous year adjusted for depreciation and industry specific time shocks divided by its total investment in that year (see eq. (7)). Since both share prices – and thus market values– and investment are highly volatile, these one period  $qm_t$ s vary considerably over the sample period. For example, the variance in  $qm_t$  is 10.4 times the variance in  $qa_t$ .<sup>18</sup> 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 is significantly related to investments in plant and equipment for the subsample of companies for which the AI hypothesis applies, we do not make this prediction for  $R\&D$ . There are significant transaction costs in expanding and contracting  $R\&D$  activities, and we do not expect  $R\&D$  to be responsive to short run changes in returns on investment. We thus exclude  $qm_{t-1}$  from the  $R\&D$

equation. Table I summarizes the predictions of the different theories. For completeness, we include the predictions from neoclassical/ $q$ -theory. A zero appears 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. Data

To calculate  $qm$  using (7) and (10) we need data on the market values and investments of each firm. 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  $t$  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 when calculating  $qm$ . Accordingly we define investment as

$$(13) \quad I = \text{After tax profits} + \text{Depreciation} - \text{Dividends} + \Delta\text{Debt} + \Delta\text{Equity} + R\&D + ADV$$

where  $\Delta\text{Debt}$  and  $\Delta\text{Equity}$  are funds raised using new debt and equity issues. Since  $R\&D$  (COMPUSTAT item 46) and advertising ( $ADV$ , item 45) can produce “intangible capital” which contributes to a company’s market value, we add them to investment to obtain a measure of a 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 (COMPUSTAT 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 item 25 (common shares outstanding)) plus the book value of preferred stock (items 56, 10, 130) plus the book value of total debt (the sum of total short term debt (item 9) and total long term debt (item 34)).<sup>19</sup> 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).<sup>20</sup> We adjust cash flow by adding the portion of  $R\&D$  that is

expensed for tax purposes.<sup>21</sup> Capital stock is measured as net fixed assets (item 8). Capital expenditures are reported in the statement of cash flows (item 128). All variables are expressed in real 1987 U.S. dollars.

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 all firms with SIC codes 5000 and above, because the nature of capital and investment in these industries is so different from that in other industries.<sup>22</sup> Other companies were dropped because investment and market values were not reported for all of the 1977 to 1996 period. To minimize the weight of outliers, we cap our variables at both the 1st and 99th percentiles, which further reduces the sample to 560 companies. Table II reports summary statistics and correlations of the variables used.

Before turning to our main findings, a few comments on Table II are warranted. As noted above, studies which have tried to test the AI hypothesis have assumed that they are small, young firms with attractive investment opportunities and such limited cash flows that they pay little or no dividends. The MD literature, on the other hand, leads one to expect that the firms which fit this hypothesis are large, mature companies with limited investment opportunities and large cash flows. These characterizations of the two types of companies are largely consistent with the figures in Table II. Companies with  $\overline{qm} < 1$  are on average roughly twice as large as those with  $\overline{qm} \geq 1$ , although their median size is about the same. Thus the distribution of firm sizes for  $\overline{qm} < 1$  companies is positively skewed with a fat right tail. An examination of the distribution of firms by industry also revealed that there were four times as many petroleum companies with  $\overline{qm} < 1$  than with  $\overline{qm} \geq 1$ . Companies with  $\overline{qm} \geq 1$  grow 3.3 times faster than  $\overline{qm} < 1$  companies, and have somewhat higher ratios of investment to total capital (means 0.29 versus



0.25). These statistics fit the small, young, fast growing image for  $\overline{qm} \geq 1$  companies, and large, mature, slow growth for the others. On the other hand, the mean dividend payout ratios are only slightly smaller for  $\overline{qm} \geq 1$  firms than for the  $\overline{qm} < 1$  firms, with the medians for the two groups being the same (0.20). Thus, clearly all of the  $\overline{qm} \geq 1$  companies were not cash constrained in all years, or they would not have paid out such high fractions of their cash flows as dividends.

From panel B it can be seen that the simple correlation between the ratio of cash flow to capital stock and Tobin's  $q$  is fairly high, 0.27. This is not surprising, since both are measures of *average* returns on capital. The correlations between cash flow and our two measures of marginal  $q$ , on the other hand, are much lower, both being around 0.12. 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.<sup>23</sup>

### **III. The Findings**

#### **A. Main Results**

Panel A in table III presents the results for investment in plant and equipment with observations pooled over the 18 year time period. For the grand sample, the coefficients on cash flow,  $qm_{t-1}$  and  $qa_{t-1}$  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  $q$ ,  $qm_{t-1}$ , takes on a positive sign as predicted, with a  $t$ -value over five. The coefficient on the interaction term between cash flow and  $qa$  is insignificant. This is not surprising, since we predict opposite signs for this coefficient for the two subsamples that make up the full sample.

Equation (2) presents the results for companies with  $\overline{qm} \geq 1$ . The coefficients on both  $qm_{t-1}$  and  $qa_{t-1}$  are positive and significant. Given that  $qm_{t-1}$  is included to capture the

attractiveness of a company's investment opportunities, we interpret the positive coefficient on  $qa_{t-1}$  as an inverse measure of the importance of AI for a company. Holding cash flow constant, companies with high  $qas$  invest more, because they have less difficulty raising cash externally. This interpretation of the role played by  $qa$  in the investment equation is reinforced by the performance of the  $qa$ /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  $qa$  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  $\overline{qm} < 1$ . In contrast with the subsample where  $\overline{qm} \geq 1$ , the interaction term between  $qa$  and cash flow is *positive* and significant for firms with  $\overline{qm} < 1$  (5% level, one-tailed test). We hypothesized that Tobin's  $q$  would proxy for MD in this subsample. Equation 3 is consistent with this hypothesis. For firms with  $\overline{qm} < 1$ , the marginal impact of cash flow on investment increases as  $qa$  increases. Tobin's  $q$  also has an independent positive and significant impact on investment. Taken together these results offer considerable support for the MD hypothesis. Many managers of firms with relatively high share prices and cash flows appear to take advantage of the discretion they have 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 a somewhat greater marginal impact of cash flow on investment for the subsamples of firms with  $\overline{qm} \geq 1$  ( $\partial I_t / \partial CF_t / K_{t-1} = 0.22$ ), than for the  $\overline{qm} < 1$  subsample ( $\partial I_t / \partial CF_t / K_{t-1} = 0.18$ ), when  $qa$  is evaluated at the respective sample means (see the last two rows). In contrast, the marginal impact of  $qa_{t-1}$  on investment is much larger for

$\overline{qm} < 1$  firms ( $\partial I_t / \partial qa_{t-1} = 0.052$ ) than for  $\overline{qm} \geq 1$  companies, ( $\partial I_t / \partial qa_{t-1} = 0.022$ ), with  $CF_t/K_{t-1}$  evaluated at its subsample mean (difference significant at 1% level).<sup>24</sup> Increases in  $qa$  appear to have a greater impact on MD 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 *marginal q* over average  $q$  as an index of investment opportunities. Marginal  $q$ ,  $qm_{t-1}$ , has a positive and significant coefficient in all three investment equations. The coefficient on  $qm_{t-1}$  for the firms with  $\overline{qm} < 1$  is, however, less than half of the value for the subsample with  $\overline{qm} \geq 1$ . The capital investment of companies that appear to be overinvesting is much less sensitive to the returns on investment than is the case for firms that are possibly cash constrained.<sup>25</sup> For the  $\overline{qm} \geq 1$  subsample, an increase in marginal  $q$ , which we interpret as an improvement in investment opportunities, has about one fourth the impact of a comparable increase in average  $q$ , which we interpret as an improvement in a firm's access to external capital (see bottom row of Panel A). In contrast, for companies with  $\overline{qm} < 1$ , an increase in average  $q$ , which we interpret as a relaxation of the threat of takeover, has *over 25 times* as large of an impact on investment as a comparable increase in marginal  $q$ . What predominantly drives the investment of companies with  $\overline{qm} < 1$  is not the height of their investment opportunities, but their resources and discretion to pursue additional investment.

We gave reasons above for expecting a weakening of the extent of MD over time. Such a development should manifest itself as a decline in the coefficients on either cash flow or  $qa$  over time. To test for this, we interacted each term in eq. (3) with  $1/t$ . 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.

The coefficients on the interaction terms with  $1/t$  were all insignificant, however. Our data reveal no tendency for the effects of managerial discretion on investment to attenuate over time. We also interacted  $1/t$  with the variables in eq. (2), and again found no tendency for the effects of asymmetric information to disappear over time. This finding suggests that the appearance of asymmetric information problems for firms in the  $\overline{qm} \geq 1$  subsample is not confined to the beginning of the sample period. Rather, AI problems would appear to arise at different points in time for different firms throughout the 18 year sample period.

Panel B of table III presents the results when  $R\&D$  is the dependent variable. The equations are identical to those for investment except that  $qm_{t-1}$  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. We see that for  $\overline{qm} \geq 1$  firms, the coefficients on both cash flow and  $qa$  are positive and significant, and the coefficient on the interaction term is negative and significant. Support for the AI hypothesis can be claimed from both the capital investment and  $R\&D$  equations.

In the  $\overline{qm} < 1$  subsample, coefficients on both the cash flow and the cash flow/ $qa$  interaction terms are positive and significant as predicted. The coefficient on  $qa$  by itself is *negative*, however. Increases in  $qa$ , which we interpret as implying increases in managerial discretion in the  $\overline{qm} < 1$  subsample, lead to increases in R&D spending only in the presence of sufficient cash flows. As can be seen in the bottom row of panel B, the marginal impact of  $qa$  on R&D is positive for a firm with the mean level of cash flows. For such a firm either an increase in cash flow or an increase in  $qa$  produces an increase in R&D spending.

The difference between the marginal effects of  $qa$  on R&D spending in the two subsamples are quite revealing. An increase in  $qa$  for a firm with the mean level of cash flows

has *nine* times the marginal impact on R&D spending for firms with  $\overline{qm} < 1$  than for firms with  $\overline{qm} \geq 1$ . For companies with sufficient cash an increase in managerial discretion over the use of that cash leads to a substantial increase in R&D spending. On the other hand, an increase in  $qa$  in the  $\overline{qm} \geq 1$  subsample implies a greater potential for raising funds in the external capital market. Our results in table III imply, however, that firms in this subsample cannot or choose not to raise external capital to finance R&D. This may be due to the intangible nature of the assets created by R&D and the greater risks surrounding this form of investment. Whatever the interpretation, the results in panel B of table III reveal a significant difference in the impact of  $qa$  on R&D spending for the two groups of companies.

In contrast, the marginal impacts of cash flows on investment are quite large and similar for the two groups. Note also the large  $t$ -values on the two cash flow coefficients and the  $R^2$ s of around 0.50 for the two equations. These are quite high for large, pooled cross-section samples like ours. Thus, the results for R&D in panel B underscore both the importance of cash flows as a source of finance for R&D, and the different reasons for this importance depending on whether a firm suffers from AI or MD problems.

## **B. Additional Splits and Robustness Checks**

Tables IV, V and VI present various robustness checks. Columns 1 to 3 in Table IV present investment equations including an accelerator term. This term is highly significant, nevertheless, the basic results concerning our hypotheses are not altered.

In Table III 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 using deviations from firm means for each variable, thereby removing firm fixed effects and effectively allowing for firm-specific rates of depreciation in the investment equation and fixed differences in *R&D* intensity across firms. The results are qualitatively similar to those reported, and are presented in columns 4 to 9 in Table IV for the basic model. Once we allow for differences in depreciation rates across firms, the coefficient for  $qm_{t-1}$  in the  $\overline{qm} < 1$  subsample becomes insignificant ( $t = 1.63$ ). This result accords with our prediction that the investment of firms that are overinvesting is unrelated to the returns on these investments. The coefficients on all other variables in both the investment and *R&D* equations are of the predicted signs except for  $qa$  in the *R&D* equation for the  $\overline{qm} < 1$  subsample. It again picks up a negative coefficient. The coefficient on the interaction term in this *R&D* equation is again quite large, however, and so the partial derivatives of *R&D* with respect to both cash flow and  $qa$  remain positive. Although the coefficients on the cash flow/ $qa$  interaction terms are all of the predicted signs, only the coefficient on this term in the *R&D* equation for firms with  $\overline{qm} < 1$  is statistically significant. The role of this interaction term in each equation is to capture the effects of differences across firms in the degrees of asymmetric information or managerial discretion on the cash flow/investment and  $qa$ /investment relationships. The effects of some of these differences across firms now appear to be accounted for by the firm effects.

Several studies have hypothesized that firm size is an important determinant of either AI or MD, or both.<sup>26</sup> 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 V splits the sample into small and large firms based on their median sales. In columns 3 and 4, the sample is further

divided into small firms with  $\overline{qm} \geq 1$  and large firms with  $\overline{qm} < 1$ .<sup>27</sup> These two subsamples might be expected to exhibit the greatest degrees of AI and MD. The results reinforce the earlier findings. In the full sample (eqs. 1 and 3), marginal  $q$ 's impact on investment is much larger and significantly different for small firms than for large firms. Cash flow has a larger (and significantly different) impact on investment for large firms than for small firms (see second last row). Both coefficients on the cash flow/ $qa$  interaction terms in columns 1 and 2 are of the predicted signs, but both are statistically insignificant. In contrast, both coefficients on these interaction terms in columns 3 and 4 are of the predicted signs and are statistically significant, despite the fact that the sample sizes in columns 3 and 4 are much smaller than in 1 and 2. This difference in results highlights the superiority of using mean marginal  $qs$  to discriminate between firms which are potentially subject to AI problems and those potentially subject to MD problems. Although small firms may be more likely to suffer from AI problems than large ones, not all small firms have these problems. In contrast, *every* firm with an AI problem should have a marginal  $q > 1$ , just as every firm with MD problems should have a  $\overline{qm} < 1$ . These criteria for identifying companies that are likely to have AI or MD problems are superior to other proxies like size.

The reader might be somewhat concerned about the weight that we place on our measures of  $\overline{qm}$  in forming the two subsamples, which we use to test the two hypotheses. As a third robustness check, therefore, we have used cutoffs of  $\overline{qm} \geq 1.1$  to form the subsample for which the AI hypothesis should hold, and  $\overline{qm} \leq 0.9$  to form the MD subsample. Equations 1 to 4 in Table VI present the results when the two subsamples are selected in this way. They closely resemble those in Table III and continue to support the two hypotheses tested. The investment and  $R\&D$  of companies with returns on investment considerably above their costs of capital fit

the AI hypothesis, the investment and *R&D* of companies with returns considerably below their costs of capital fit the MD hypothesis.

Two additional criteria for splitting the sample, given the logic underlying the two hypotheses, are by dividend payments and Tobin's  $q$ .<sup>28</sup> Firms subject to AI problems should be cash-constrained and thus pay no (little) dividends *and* earn high returns on investment. The investment of firms with  $\overline{qm} \geq 1$  *and*  $qa < 1$  should be most susceptible to cash constraints problems, while managers of companies with  $\overline{qm} < 1$  *and*  $qa > 1$  are most likely to have the discretion to overinvest and to be using it. Such splits using dual criteria greatly reduce the numbers of observations in each subsample. Nevertheless, the predictions of the two hypotheses continue to be confirmed.<sup>29</sup>

We have stressed the importance for investment models of the distinction between marginal and average  $q$ . 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  $qa$  may have conceptual advantages for other purposes, we think that this simple measure is well-suited for the role  $qa$  plays in our model – particularly with respect to the AI 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  $qa$  as in Lindenberg and Ross (1981), or in Kaplan and Zingales (1997),<sup>30</sup> or when we adjust its denominator for the intangible capital stock due to *R&D*.<sup>31</sup>



#### IV. Conclusions

Our goal has been to shed light on the question of why investment outlays are so strongly correlated with cash flows. To do so we have tested the two leading hypotheses about this question – the AI and MD hypotheses. To conduct these tests it was necessary to identify the firms that may fit each hypothesis. Since the AI hypothesis predicts that firms underinvest and have returns on investment greater than their costs of capital, while the MD hypothesis predicts overinvestment and returns on investment less than the costs of capital, using the ratio of returns on investment to costs of capital for each firm is a natural way to make this identification. We have constructed such a ratio and divided our sample of 560 companies by it. The data support both hypotheses for their respective subsamples of firms.

Unlike most recent studies we did not use Tobin's  $q$  to control for differences in investment opportunities, because it measures the ratio of a firm's *average* return on capital to its cost of capital, while for investment what is relevant is a ratio that includes the *marginal* return on capital. Our marginal  $q$ ,  $qm_t$ , is such a ratio. It was found to be a significant determinant of investment for the AI subsample. With investment opportunities controlled for by the inclusion of  $qm_{t-1}$  in the equation, we could conclude with some confidence that cash flow's positive relationship to investment was due to its role as a source of finance.

Although we did not use Tobin's  $q$  ( $qa$ ) to control for differences in investment opportunities, it did play an important role in the tests of the two hypotheses. In the AI subsample, the sensitivity of investment and  $R\&D$  to internal cash flows *declined* as  $qa$  increased because, we hypothesized, the cost of external funds for these firms declines as  $qa$  rises.

As predicted, increases in  $qa$  *increased* the sensitivity of investment and  $R\&D$  to internal cash flows for companies with returns on investment less than their costs of capital. As  $qa$  rises managers feel less threatened by hostile takeovers, and thus have more freedom to use their

companies' cash flows to pursue their own goals. Investment and  $qm_{t-1}$  were more weakly related in the MD subsample than for the AI subsample, and the coefficient on  $qm_{t-1}$  became insignificant with firm effects removed. The investment decisions of firms earning returns on investment below their costs of capital are likely to be driven by other objectives than maximizing shareholder wealth, and consequently are more closely related to the measures of MD – cash flow and  $qa$  – than to the heights of their investment opportunities.

The findings of this article have potentially important policy implications. At any point, some firms are under investing because of a shortage of cash, others are over investing because of an excess of managerial discretion. Any governmental policies that increase the investment levels of all firms, mitigate the first problem while aggravating the second. Optimal investment policies would target funds to companies suffering from asymmetric information problems and extract funds from companies with agency problems. Space precludes our taking up these issues here, but we hope to have at least demonstrated their relevance.

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**Table I**

**Predicted Signs of Coefficients from the Different Theories**

Theory	Neoclassical/ q-theory		Asymmetric Information		Managerial Discretion	
Sample	All firms		Firms with $\overline{qm} \geq 1$		Firms with $\overline{qm} < 1$	
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	+	+	+	+	+	+
$CF_t/K_{t-1}$	0	0	+	+	+	+
$qm_{t-1}$	NA	NA	+	?	?	?
$qa_{t-1}$	+	+	+	+	+	+
$qa_{t-1} * CF_t/K_{t-1}$	0	0	-	-	+	+

Note:  $\overline{qm}$  is the calculated sample period marginal  $q$

$CF_t/K_{t-1}$  is cash flow divided by the book value of capital stock lagged one period

$qm_{t-1}$  is our yearly measure of marginal  $q$  lagged one period

$qa_{t-1}$  is Tobin's  $q$  lagged one period

$qa_{t-1} * CF_t/K_{t-1}$  is an interaction term of Tobin's  $q$  and cash flow

NA = not applicable. Under the neoclassical theory  $qa$  should equal  $qm$  and only one variable enters the equation.

**Table II**

**Summary Statistics and Correlation Matrix**

**Panel A. Summary Statistics**

<i>Variables:</i>	All			$\overline{qm} \geq 1$			$\overline{qm} < 1$		
	Mean	Med	S.D.	Mean	Med	S.D.	Mean	Med	S.D.
<i>Sales (Mn. \$)</i>	2835.9	383.1	8774.6	1698.3	374.3	4441.4	3290.9	391.3	9959.1
<i>DSAL</i>	0.039	0.026	0.277	0.078	0.054	0.289	0.024	0.014	0.271
<i>Div. Payout Ratio</i>	0.241	0.202	0.645	0.210	0.202	0.207	0.258	0.207	0.754
$I_t/K_{t-1}$	0.263	0.221	0.169	0.291	0.253	0.75	0.252	0.211	0.165
$R_t/K_{t-1}$	1.139	0.082	0.164	0.149	0.089	0.158	0.136	0.079	0.166
$qa_{t-1}$	1.136	0.966	0.597	1.504	1.334	0.736	0.989	0.874	0.454
$qm_{t-1}$	0.769	0.794	1.900	1.131	1.120	2.035	0.582	0.663	1.797
$CF_t/K_t$	0.370	0.311	0.312	0.432	0.378	0.312	0.345	0.281	0.308
<i>Number of Firms</i>		560			167			393	
<i>Number of Obs.</i>		7,361			2,103			5,258	

**Panel B. Matrix of Correlation Coefficients: All firms**

	$\overline{qm}$	$qa_{t-1}$	$I_t/K_{t-1}$	$R_t/K_{t-1}$	$CF_t/K_t$	<i>DSAL</i>	<i>Sales</i>	$qm_{t-1}$
$\overline{qm}$	1							
$qa_{t-1}$	0.398	1						
$I_t/K_{t-1}$	0.081	0.199	1					
$R_t/K_{t-1}$	0.020	0.204	0.318	1				
$CF_t/K_t$	0.121	0.272	0.436	0.618	1			
<i>DSAL</i>	0.090	0.139	0.281	0.183	0.385	1		
<i>Sales</i>	-0.083	-0.095	-0.022	-0.077	-0.083	-0.012	1	
$qm_{t-1}$	0.037	0.186	0.115	0.026	0.119	0.149	-0.015	1

Note:  $\overline{qm}$  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 expenditures 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

$qa_{t-1}$  is Tobin's q calculated as the market value of equity plus the value of debt divided by total assets

$qm_{t-1}$  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**  
**Panel A: OLS regression results with I/K as dependent variable**

Equation	1		2			3	
Sample	All		$\overline{qm} \geq 1$			$\overline{qm} < 1$	
	Coef	t-val	Coef	t-val		Coef	t-val
$CF_{t-1}/K_{t-1}$	0.199	15.93	0.298	11.35	>	0.153	9.93
$qm_{t-1}$	0.003	5.42	0.005	4.21	>	0.002	3.29
$qa_{t-1}$	0.039	8.11	0.043	5.35	$\approx$	0.045	6.17
$qa_{t-1} * CF_{t-1}/K_{t-1}$	-0.007	-0.87	-0.049	-3.79	<	0.021	1.86
Firms	560		167			363	
No. Obs.	7,361		2,103			5,258	
$\bar{R}^2$	0.23		0.22			0.23	
Predicted partial derivatives (evaluated at respective means):							
$CF_{t-1}/K_{t-1}$	0.191*		0.224*		>	0.175*	
$qa_{t-1}$	0.037*		0.022*		<	0.052*	

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

Equation	1		2			3	
Sample	All		$\overline{qm} \geq 1$			$\overline{qm} < 1$	
	Coef	t-val	Coef	t-val		Coef	t-val
$CF_t/K_{t-1}$	0.273	27.98	0.294	15.77	>	0.229	18.49
$qa_{t-1}$	-0.002	-0.58	0.012	2.19	>	-0.011	-1.91
$qa_{t-1} * CF_{t-1}/K_{t-1}$	0.007	1.17	-0.026	-2.84	<	0.059	6.32
Firms	560		167			363	
No. Obs.	7,361		2,103			5,258	
$\bar{R}^2$	0.49		0.49			0.50	
Predicted partial derivatives (evaluated at respective means):							
$CF_{t-1}/K_{t-1}$	0.281*		0.254*		<	0.288*	
$qa_{t-1}$	0.001		0.001		<	0.009**	

\* Significant at the 1% level, \*\* at 5% level.

Note: <, >,  $\approx$  means significantly smaller, larger or not significantly different, respectively. The  $qa$  /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. For the other variable definitions see tables I and II.

**Table IV**

**Robustness I: Different Specifications and Firm Fixed Effects**

Sample	OLS			Fixed Effects								
	All	I/K		All	I/K			R/K				
		$\overline{qm} \geq 1$	$\overline{qm} < 1$		$\overline{qm} \geq 1$	$\overline{qm} < 1$	All	$\overline{qm} \geq 1$	$\overline{qm} < 1$			
1	2	3	4	5	6	7	8	9				
Accelerator	0.032	0.032	≈	0.031								
t-value	13.88	6.52		12.03								
$CF_{t-1}/K_{t-1}$	0.159	0.249	>	0.119	0.211	0.280	>	0.183	0.130	0.170	>	0.103
t-value	12.59	9.22		7.66	15.22	9.74		10.97	18.86	12.34		12.29
$qm_{t-1}$	0.003	0.004	>	0.002	0.002	0.002	≈	0.001				
t-value	4.40	3.36		2.63	2.69	2.11		1.63				
$qa_{t-1}$	0.039	0.043	≈	0.045	0.052	0.036	<	0.071	-0.001	0.011	>	-0.012
t-value	8.03	5.37		6.31	8.04	3.52		7.99	-0.41	2.39		-2.89
$qa_{t-1} * CF_{t-1}/K_{t-1}$	-0.005	-0.043	<	0.020	0.004	-0.014	≈	0.012	0.021	-0.005	<	0.046
t-value	-0.63	-3.35		1.80	0.51	-0.99		1.02	4.97	-0.72		7.62
Firms	560	167		393	560	167		393	560	167		393
No. Obs.	7,361	2,103		5,258	7,361	2,103		5,258	7,361	2,103		5,258
$\bar{R}^2$	0.25	0.23		0.25	0.34	0.30		0.35	0.82	0.80		0.83

Note: <, >, ≈ means significantly smaller, larger or not significantly different, respectively, where the  $qa$ /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 V****Robustness II: Split according to firm size, I/K**

Sample	All		$\overline{qm} \geq 1$		$\overline{qm} < 1$	
	Small 1		Large 2	Small 3		Large 4
$CF_{t-1}/K_{t-1}$	0.169	<	0.266	0.289	>	0.191
t-value	10.05		12.92	8.01		6.98
$qm_{t-1}$	0.004	>	0.001	0.006	>	0.001
t-value	4.53		2.01	3.62		1.38
$qa_{t-1}$	0.047	>	0.021	0.044	>	0.003
t-value	6.26		3.10	3.59		0.31
$qa_{t-1} * CF_{t-1}/K_{t-1}$	-0.005	$\approx$	0.0004	-0.048	<	0.092
t-value	-0.46		0.03	-2.76		4.21
Firms	280		280	112		207
No. Obs.	3,680		3,680	1,067		2,644
$\overline{R}^2$	0.19		0.32	0.19		0.34
Predicted partial derivatives (evaluated at respective means):						
$CF_{t-1}/K_{t-1}$	0.164*	<	0.266*	0.218*	<	0.281*
$qa_{t-1}$	0.045*	>	0.022*	0.022*	$\approx$	0.029*

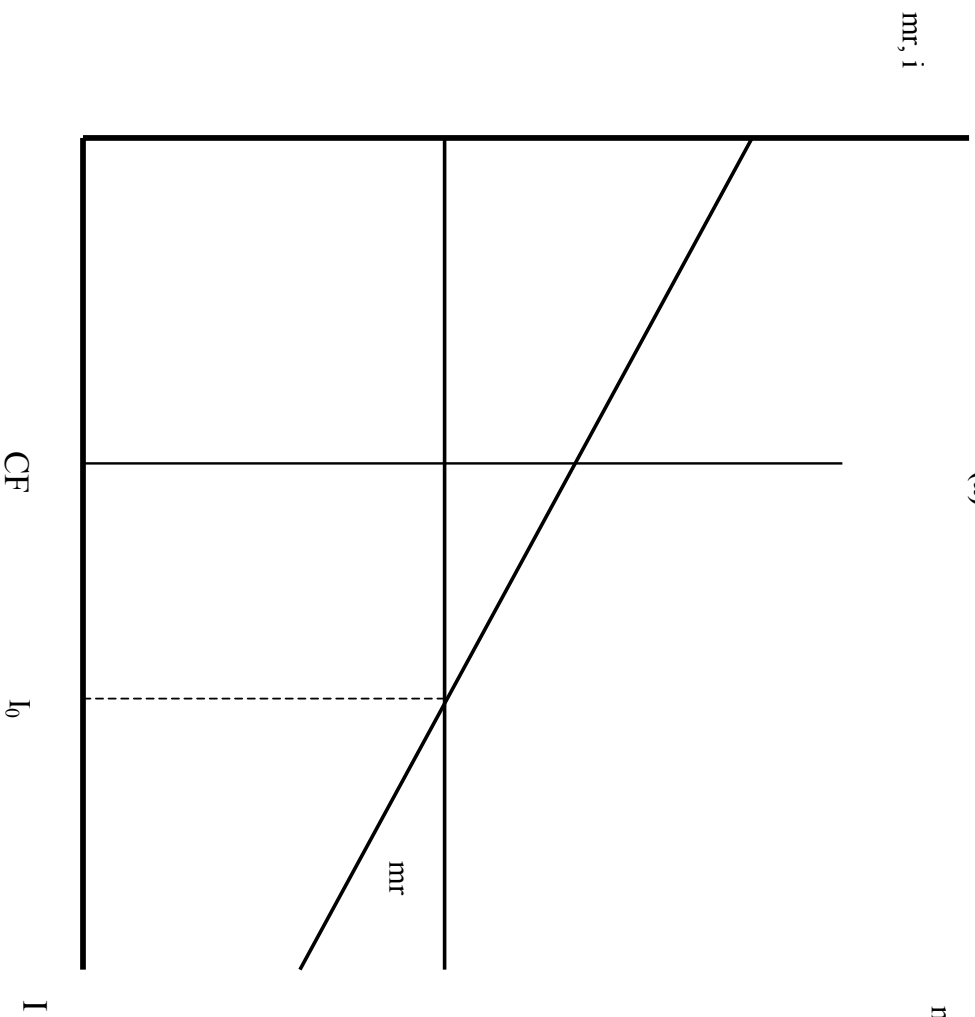
Note: Small: Annual sales < median sales; Large: Annual sales > median sales.

**Table VI**

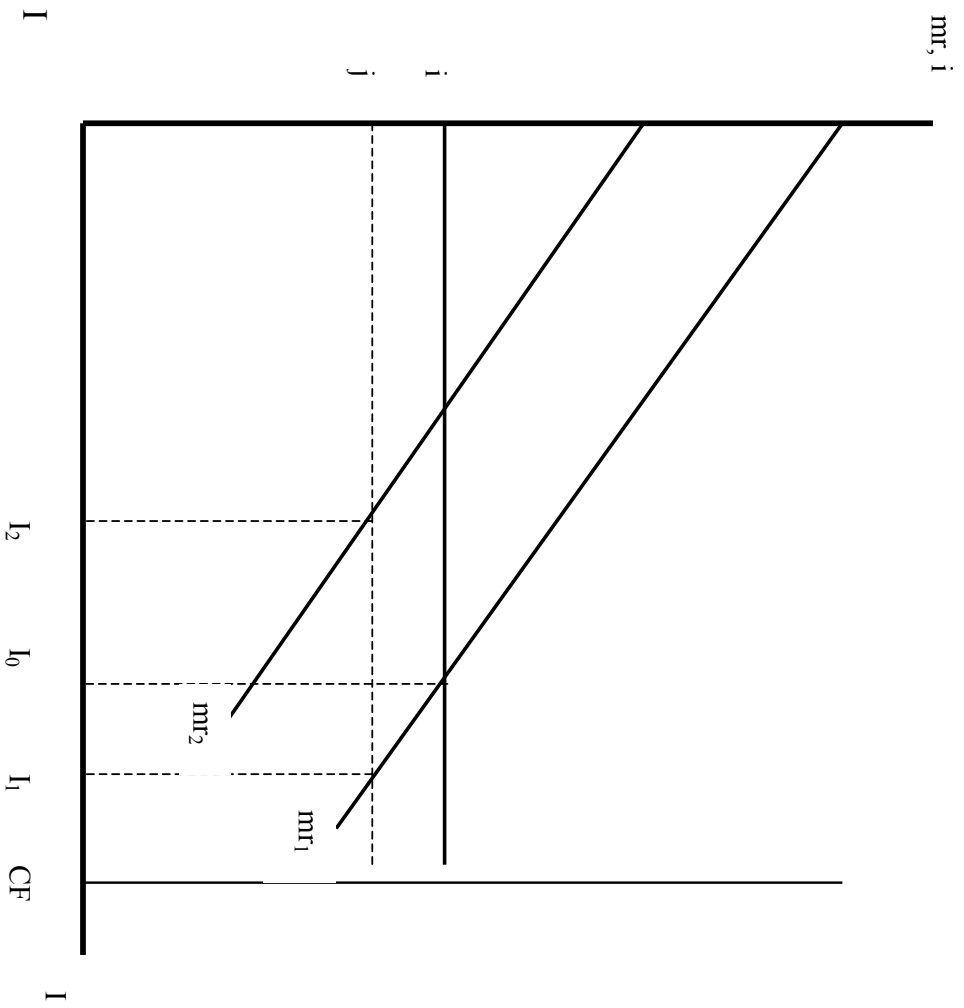
**Robustness III: Splits by  $\bar{q}_m \geq 1.1$  and  $\bar{q}_m \leq 0.9$**

	I/K				R&D/K						
	1		2		3		4				
	$\bar{q}_m \geq 1.1$		$\bar{q}_m < 0.9$		$\bar{q}_m \geq 1.1$		$\bar{q}_m < 0.9$				
	Coef	t-val		Coef	t-val		Coef	t-val			
$CF_t/K_{t-1}$	0.280	9.48	>	0.157	9.87		0.323	15.32	>	0.238	18.39
$qm_{t-1}$	0.005	3.65	>	0.002	2.07						
$qa_{t-1}$	0.041	4.62		0.044	5.76		0.022	3.52	>	-0.009	-1.50
$qa_{t-1} * CF_t/K_{t-1}$	-0.040	-2.91	<	0.025	3.58		-0.040	-4.02	<	0.059	5.98
Firms	134			366			134			366	
No. Obs	1,662			4,938			1,662			4,938	
$\bar{R}^2$	0.21			0.24			0.51			0.50	
Predicted partial derivatives (evaluated at respective means):											
$CF_t/K_{t-1}$	0.216*		>	0.182			0.260*		<	0.296*	
$qa_{t-1}$	0.023*		<	0.053			0.005		<	0.010**	

**Figure 1**  
**Investments with  $\overline{qm} \geq 1$  and  $\overline{qm} < 1$**   
**(a)**



**(b)**



## Notes

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- <sup>1</sup> Meyer and Kuh (1957) is the pioneering study. Chirinko (1993) presents a comprehensive survey of the investment determinants literature.
- <sup>2</sup> The transaction costs hypothesis was first developed by Duesenberry (1958). Grabowski and Mueller (1972) were the first to hypothesize that the cash flow/investment relationship was caused by agency problems. The first empirical test of the asymmetric information hypothesis was by Fazzari, Hubbard and Petersen (1988).
- <sup>3</sup> See Stiglitz and Weiss (1981) and Myers and Majluf (1984).
- <sup>4</sup> See, Fazzari, Hubbard and Petersen (1988), Hoshi, Kashyap and Scharfstein (1991), Carpenter (1995), Carpenter, Fazzari, and Petersen (1994, 1998) and Chirinko and Schaller (1995).
- <sup>5</sup> See Kaplan and Zingales (1997) for further discussion and evidence.
- <sup>6</sup> It is always possible, of course, that a firm earned higher returns on investment than its cost of capital because its managers underestimated these returns, or were merely overly cautious (Kaplan and Zingales, 2000, p. 711), and not because the firm was cash constrained. Hence, the modifier “possibly.”
- <sup>7</sup> Marris (1964, 1998) first motivated and developed the growth maximization hypothesis.
- <sup>8</sup> Hayashi (1982) demonstrates that marginal  $q$  is the theoretically correct measure of investment opportunities and establishes the conditions under which it equals average  $q$ . Osterberg (1989) proves that marginal  $q$  is a “sufficient statistic” for investment.
- <sup>9</sup> Other attempts to come up with a measure of marginal  $q$ , which differ from ours’ include Abel and Blanchard (1986), Gilchrist and Himmelberg (1995) and Cummins, Hassett and Oliner (1998).
- <sup>10</sup> 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, which could imply a reduction in agency problems after 1988.
- <sup>11</sup> See again, Hayashi (1982) for a formal development of the theory.
- <sup>12</sup> This derivation was first presented by Mueller and Reardon (1993). For other applications and additional discussion, see Mueller and Yurtoglu (2000) and Gugler and Yurtoglu (forthcoming).
- <sup>13</sup> For further discussion of this possible bias see Mueller and Yurtoglu (2000, pp. 194-95).
- <sup>14</sup> Indeed, if all companies with  $\overline{qm} \geq 1$  had investment opportunities as depicted in figure 1a, and none could raise any external capital, their investments should exactly equal their cash flows, and the

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coefficient on cash flow in an investment equation for this subsample would equal 1.0.

- <sup>15</sup> Kaplan and Zingales (1997, 2000) are concerned about previous studies' failure to control for differences in the costs of external finance across "cash-constrained" companies. Our use of  $qa$  should capture an important component of these differences.
- <sup>16</sup> 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.
- <sup>17</sup> Some studies have lagged cash flow also on the grounds that managers need some time to react to changes in cash flows. We also estimated the model substituting cash flow lagged one period for the current level, and obtained very similar results to those reported here. These are available from the authors upon request.
- <sup>18</sup> The standard deviations of each variable appear in Table II.  $(1.9)^2/(0.597)^2 = 10.4$ .
- <sup>19</sup> We tried a number of other definitions of Tobin's  $q$ , see the discussion in section III.
- <sup>20</sup> By defining cash flow to be net of dividends, we effectively assume that dividends have higher priority than investment, and are determined before it. This assumption appears particularly appropriate for the MD subsample, since dividends for these firms should be positively related to share prices and are a means of "buying" security from takeover. Substituting a pre-dividend definition of cash flow produces very similar results to those reported here. These are again available from the authors on request.
- <sup>21</sup> We add  $(1 - \text{tax rate})$  times the R&D expenditures to cash flow. The tax rate that we use is 50 % for the 1979-1987 period and 34 % for the 1988-1996 period.
- <sup>22</sup> When the model was estimated for firms in these industries, the results were largely consistent with our predictions for capital investment. Companies in these industries do little *R&D* (median firm zero), and so not surprisingly the fit for the *R&D* equation was poor.
- <sup>23</sup> 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 MD and AI hypotheses to explain such a relationship.

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- <sup>24</sup> Throughout the paper all partial derivatives with respect to either  $CF_t$  or  $qa_{t-1}$  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 subsamples. Statistical insignificance between regression coefficients is indicated by an equality sign between columns 2 and 3.
- <sup>25</sup> We argued above that there might actually be no relationship between  $qm_{t-1}$  and  $I_t$  for firms with  $\overline{qm} < 1$ , but this prediction was obviously too strong.
- <sup>26</sup> See e.g. Vogt (1994), Bond and Meghir (1994) and Kadapakkam et al. (1998).
- <sup>27</sup> The results for small and  $\overline{qm} < 1$  firms and for large and  $\overline{qm} \geq 1$  firms lie in between the two "extreme" subsamples and are available from the authors upon request.
- <sup>28</sup> A split by dividends underlay the test of the AI hypothesis in the seminal contribution of Fazzari, Hubbard and Petersen (1988).
- <sup>29</sup> Results available from the authors upon request.
- <sup>30</sup> 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  $qa$  and obtained the following results (detailed results are available upon request). (1) When we define  $qa$  in spirit of Kaplan and Zingales (1997) ( $qa = (\text{market value of the firm plus total assets minus book value of common equity minus balance sheet deferred taxes}) / \text{total assets}$ ), all of our results carry over, some are even more pronounced. (2) When we define it in the spirit of Lindenberg and Ross (1981) ( $qa = (\text{market value of the firm}) / (\text{total assets plus replacement cost of fixed assets minus book value of fixed assets plus LIFO reserve plus total debt minus total liabilities})$ ), all results carry over qualitatively although there is some reduction in significance.
- <sup>31</sup> We thank Bruce Petersen for suggesting this test. We estimated  $R\&D$  capital as  $R\&D$  spending times 5 or 10 assuming that the firm is in a steady state and the  $R\&D$  stock depreciates at a constant 20% or 10% rate. These rates are consistent with the range of depreciation rates presented in the literature (Nadiri and Prucha, 1996). With  $qa$  defined as the ratio of the market value to total assets plus this  $R\&D$  stock,  $qm_{t-1}$  remains much more important for the  $\overline{qm} \geq 1$  firms compared to  $\overline{qm} < 1$  firms, and the reverse is true for  $qa$ . The cash flow /  $qa$  interaction term is negative for the  $\overline{qm} \geq 1$  subsample and positive for the  $\overline{qm} < 1$  subsample, however, the difference is now not significant at conventional level.