INVESTMENT SMOOTHING WITH WORKING CAPITAL: NEW EVIDENCE ON THE IMPACT OF FINANCIAL CONSTRAINTS

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NEW EVIDENCE ON THE IMPACT OF FINANCIAL CONSTRAINTS

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Abstract:

This paper links research on both capital market imperfections and smoothing behavior to the study of investment. Our approach emphasizes two basic aspects of firms' production technology: (1) costs of adjusting the fixed capital stock, and (2) the importance of working capital as a reversible input in the production process. We argue that while financing constraints will likely prevent firms from equating the marginal returns on investment over time, they should not prevent the firm from equating the marginal returns on different investment inputs, net of adjustment costs, at each point in time. In particular, high adjustment costs for fixed capital should cause financially constrained firms to smooth fixed capital investment relative to cash flow shocks by optimally adjusting working capital.

Incorporating working capital changes in econometric investment equations, as motivated by our smoothing model, leads to a substantially larger impact of internal finance on fixed investment than found in the recent literature. Furthermore, the positive relationship between cash flow and investment found in a number of recent studies might reflect shifts of investment demand rather than finance constraints. The results we find for working capital and cash flow together, however, are inconsistent with the view that internal finance variables proxy investment demand fluctuations. Rather, the results here provide strong evidence that finance constraints are a key determinant of investment for a large fraction of U.S. manufacturing firms.

I. Introduction

Recent theoretical developments, particularly those that analyze the effects of asymmetric information, explain why the level of internal finance may be a binding constraint on the level of investment for some firms.[1] A number of empirical studies support this proposition, a finding with potentially important implications for industrial organization and public finance, as well as macroeconomics. Empirical research has proceeded along two lines: (1) reduced-form regressions of investment on cash flow,[2] and (2) tests of financial constraints using Euler equation methods.[3] Both approaches have important limitations. The reduced-form approach has the potential shortcoming that cash flow may proxy investment demand rather than the effects of binding financial constraint on investment, even after including variables to control for demand effects, such as Tobin's q.[4] A limitation of the Euler equation hypothesis tests is that they do not indicate the quantitative economic importance of internal finance constraints. Furthermore, rejections of the Euler condition could arise because the production technology or adjustment costs are misspecified rather than the existence of binding finance constraints.[5]

This paper addresses these problems in the existing literature by emphasizing two basic aspects of firms' production technology: (1) costs of adjusting the capital stock, and (2) the importance of working capital as a reversible input in the production process. Fixed capital adjustment costs are a central feature of standard investment models. They give firms an incentive to smooth fixed capital investment for reasons similar to those developed in the consumption smoothing and production smoothing literature. The importance of working

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[1] Seminal papers include Stiglitz and Weiss (1981) and Myers and Majluf (1984). For extensive references to recent research see the survey by Gertler (1988).

[2] See Meyer and Kuh (1957) and Eisner (1978) for early contributions. Recent papers include Fazzari and Athey (1987), Fazzari, Hubbard and Petersen (1988, hereafter denoted by FHP), Gertler and Hubbard (1988), Hoshi, Kashyap and Scharfstein (1988), Devereux and Schianterelli (1989), and Oliner and Rudebusch (1989).

[3] See Whited (1988), Gilchrist (1989), Hubbard and Kashyap (1990), and Himmelberg (1990).

[4] Poterba (1988, p. 201) provides an excellent summary of this point. "If ... measured Q provides an error-ridden indicator of firms' true prospects, then econometric results may find that current cash flow affects investment only because this variable, just like measured Q, is correlated with the 'true' marginal Q variable that firms consider in making investment decisions."

[5] See, for example, the discussion of this point in Gilchrist (1989).

capital in production has been recognized by economists since Adam Smith, and it has been explicit in accounting for at least four centuries.[6] While it is often ignored by modern economists, the value of working capital is quantitatively of the same order of magnitude as fixed capital.[7]

Our basic argument is as follows. In theory, the existence of financing constraints will likely prevent firms from equating the marginal returns on investment over time because of fluctuations in their internal finance or internal net worth. (This idea motivates research that tests whether the Euler condition arising from firms' dynamic optimization problem in perfect capital markets is satisfied.) Financial constraints, however, should not prevent firms from equating expected marginal returns on different investment inputs, net of adjustment costs, at each point in time. Therefore, high adjustment costs for fixed capital may cause financially constrained firms to smooth fixed capital investment through disproportionately large changes in working capital when cash flow fluctuates. Furthermore, while we argue that working capital is a readily reversible investment, the marginal opportunity cost of sacrificing working capital to smooth fixed investment will depend on the firm's initial stock of working capital, an important component in measuring the strength of a firm's balance sheet.[8]

These ideas lead to several empirical implications for the link between investment and internal finance. First, because working capital investment is substantial relative to fixed capital investment, one would not expect the reduced-form impact of cash flow on fixed investment to exceed one less the share of working capital investment, even for firms that have no access whatsoever to external finance. Also, the estimated coefficients on cash flow in most recent reduced-form investment studies capture only the average "short-run" impact of cash flow on fixed investment because firms can smooth fixed investment relative to short-run fluctuations in

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[6] Dewing (1941, p. 707) points out that the balance sheet prepared in 1571 by the Society of Mines Royal clearly divided capital into "current" and fixed components.

[7] In manufacturing, for example, the Statistics of Income show that the stock of working capital is more than half as large as the stock of fixed capital.

[8] This kind of result is related to "internal net worth" arguments emphasized by Gertler and Hubbard (1988), Bernanke and Gertler (1989), Calomiris and Hubbard (1990), and Hubbard and Kashyap (1990).

cash flow.[9] Indeed, if financially constrained firms engage in fixed investment smoothing, they may come sufficiently close to equating intertemporal marginal returns to prevent an Euler equation test from detecting the presence of finance constraints. To measure the full "long-run" effect of internal finance, one must account explicitly for investment smoothing.

Perhaps most importantly, our approach addresses the central criticism of decades of evidence on the reduced-form link between cash flow and investment. Because changes in cash flow correlate highly with changes in profits, cash flow effects on investment have been interpreted as proxies for profit-driven shifts in investment demand rather than evidence of financial constraints. Our approach helps resolve this identification problem. The "profit signal" interpretation would predict that changes in working capital, another potential signal of future profits in reduced-form investment equations, will have a positive effect on investment and reduce the strength of the cash flow effect. Our analysis of fixed investment smoothing with working capital generates just the opposite predictions. Because reductions in working capital, for example, are a source of funds to maintain smooth fixed investment when cash flow falls changes in working capital should have a *negative* coefficient when included as an endogenous variable in a fixed investment regression. Therefore, the impact of changes in working capital in the investment equation clearly distinguishes between competing explanations for the observed internal finance - investment link.

We test our predictions with firm panel data. Most of our tests focus on a group of zero-dividend firms. These firms are especially likely to face binding financing constraints, as indicated by FHP (1988) and Gilchrist's (1990) rejection of the Euler condition for zero-dividend firms. It is important to note that these firms constitute a significant portion of the economy; even among publicly-traded companies listed by Compustat, zero-dividend firms account for more than half of the sample in recent years.

Our empirical findings strongly support the joint hypotheses of financial constraints and fixed investment smoothing with working capital. We present tests of investment smoothing analogous to the production smoothing tests used by Blinder (1986). The evidence on the variability of working capital changes, internal finance, and fixed investment are consistent with our predictions. We present investment regressions

[9] Blinder (1988) emphasizes the importance of liquidity for the investment of financially constrained firms. This concern in the empirical literature goes back at least to Meyer and Kuh (1957).

with and without changes in working capital, entered as an endogenous variable using instruments motivated by the economic structure of our analysis. The regression coefficient for working capital is negative and highly significant. Furthermore, our results indicate that previous studies substantially underestimated the economic impact of finance constraints on fixed investment because they did not account for the dual role of changes in working capital as a claim on scarce internal finance and a reversible asset that can be used to smooth fixed investment.

The next section of the paper reviews firms' incentives to smooth fixed investment and the impediments to smoothing arising from capital market imperfections. Section III motivates our empirical tests by considering the optimal investment problem of a firm that employs two kinds of capital with different adjustment costs and faces a binding finance constraint. We describe the data sample in section IV and present the empirical results in section V. The concluding section mentions some of the implications of our results for industrial organization and macroeconomics.

II. INVESTMENT SMOOTHING AND CAPITAL MARKETS

II.A. Related Literature

Standard neoclassical theories (Holt, Modigliani, Muth, and Simon, 1960, for example) predict that firms will seek to smooth production relative to sales if cost functions are sufficiently concave. As noted by Blinder (1986), however, the empirical evidence for production smoothing is mixed.[10] Consumption smoothing is a central theme of the life cycle and permanent income models. If utility functions are time separable and marginal utility declines with rising consumption, consumers will choose, if possible, to smooth consumption relative to fluctuations of income. If capital markets allow consumers to freely borrow against their lifetime wealth, generated by human as well as tangible capital, consumers face no impediments to achieving an optimally smooth consumption profile.

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[10] The literature is too large to allow detailed citations here. See Ramey (1989) for a recent list of references.

There is an extensive empirical literature that tests the implications of the life cycle / permanent income theories of consumption along with their implications about consumption smoothing. Recently, a key question addressed in this research is whether capital market problems limit the extent of consumption smoothing. The evidence summarized in Hayashi's (1987) survey suggests that a significant fraction of consumers are liquidity constrained. Furthermore, as Zeldes (1989) argues, even consumers that face borrowing constraints can use changes in liquid asset stocks to smooth consumption. This point is related to the tests of investment smoothing by financially-constrained firms pursued here.

II.B. Incentives for Investment Smoothing

The incentives for firms to smooth investment are similar to the motivation behind production and consumption smoothing. Since the seminal work of Eisner and Strotz (1963) and Lucas (1967), the most common explanation for investment smoothing is that marginal adjustment costs of acquiring and installing capital rise as the rate of investment increases. Sargent (1979, p. 127) summarizes the central importance of adjustment costs to investment theory, "the key to the theory is the assumption that there are costs associated with adjusting the capital stock at a rapid rate per unit of time and that these costs increase rapidly with the absolute rate of investment, so rapidly that the firm never attempts to achieve a jump in its capital stock at any moment." For example, quadratic adjustment costs are typically used to formally derive a relationship between Tobin's q and investment.[11]

Another motivation for investment smoothing arises because firms cannot costlessly store or delay investment projects, a problem of special importance in fast-growing, innovation-intensive industries. In such industries, in which small, zero-dividend firms are likely to predominate, new investment opportunities arise each period because of past innovative activity. If these opportunities are not undertaken as they arise, their value to the firm rapidly decays because of short product life cycles and the first-mover advantage from

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[11] See, for example, the work of Abel (1979), Summers (1981), Hayashi (1982), and Chirinko (1987).

commercializing new technologies.[12] With rapid obsolescence of investment opportunities, a firm's incentive to smooth investment, assuming project opportunities arrive at a relatively constant rate, is similar to an individual's incentive to smooth consumption under the standard assumptions of time separable utility functions with declining marginal utility of consumption.[13]

II.C. Impediments to Investment Smoothing Arising From Financial Constraints

In perfect capital markets, firms would determine their optimal investment program from their production technology as well as considerations arising from convex adjustment costs, perishability of investment projects, etc. Financial factors would not prevent firms from optimal investment smoothing, and the real capital accumulation path followed by the firm would be independent of its financial structure.

Much recent research on the functioning of capital markets, however, suggests that real investment may not be independent of financial factors. FHP (1988) provides an extensive list of references to research on how asymmetric information in capital markets can create financial constraints. Briefly, the arguments rest on the distinction between "insiders" with full information about a particular firm's investment prospects, and "outsiders" that may correctly perceive the prospects for a population of firms, but cannot distinguish the quality of individual firms. This information structure can lead to both adverse selection and moral hazard in markets for external finance. In a seminal paper, Stiglitz and Weiss (1981) argue that credit rationing may emerge in debt markets with asymmetric information because increased interest rates can lower lenders' profits. This result occurs if higher interest rates either cause relatively good firms to leave the applicant pool (adverse selection), or if higher interest rates cause firms to undertake riskier projects (moral hazard). In external equity markets, new investors may be asymmetrically informed about the true value of firms' existing assets and new

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[12] Myers and Majluf (1984) recognize the lack of storability for many kinds of investment projects. Personal computers is an example of an industry in which the product cycle appears to be less than two years.

[13] Suppose the firm faces a new, downward-sloping marginal efficiency of investment schedule each period and that projects cannot be stored for future periods. The firm will maximize its value by maintaining a smooth investment profile to equate its marginal returns over time. If investment is driven by fluctuations in cash flow, the firm would sacrifice relatively high-valued projects in lean years for low-valued projects in years with higher than average cash flow.

investment opportunities. Myers and Majluf (1984) extend Akerlof's (1970) "markets-for-lemons" argument to explain why firms may be forced to sell new shares at a discount, if they can sell shares at all.[14]

The combination of credit rationing and the "lemons premium" in external equity markets may result in a pronounced financing hierarchy (see Myers, 1984) in which some firms find it optimal to retain all their earnings but not to issue new equity shares. Numerous empirical studies (see footnotes 2 and 3 for a partial list) have found evidence that at least some firms do appear to face financing constraints, in the sense that variations in internal finance affect real investment. These constraints limit the firm's ability to smooth fixed investment with external funds when sources of internal finance fluctuate. But financially constrained firms will still have an incentive to smooth fixed investment by changing the stock of reversible assets. As we will show, this incentive has fundamental implications for how the existing empirical results should be interpreted, and it motivates new tests that identify much larger internal finance effects than those estimated in previous research.

III. THEORETICAL FRAMEWORK AND EMPIRICAL IMPLICATIONS

III.A. Working Capital and Investment Smoothing

To motivate our empirical tests, we consider the investment problem of a firm that employs both fixed and working capital and faces a binding finance constraint. For our purposes, the reversibility of working capital is an important property. Thus, for a financially constrained firm, working capital plays a dual role as a potential source of liquidity and an input into production. Because of high adjustment costs for fixed capital, we argue that firms should smooth fixed investment with changes of working capital; that is, even if financing constraints prevent the firm from equating marginal returns on investment over time, they should still be able to equate the marginal returns on different kinds of capital, net of adjustment costs, at each point in time.

Working capital is typically defined as current assets less current liabilities. Current assets consist primarily of accounts receivable, inventories, and cash and equivalents. On average, accounts receivable exceed

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[14] Greenwald and Stiglitz (1990, p. 34) examine adverse selection in equity markets, concluding that "asymmetric information may well restrict equity issues to a small number of firms and an insignificant amount of funds, as it appears in practice."

inventories, which in turn greatly exceed cash and equivalents. Inventories include materials, work-in-process, and finished goods. On average, materials exceed work-in-process which is greater than finished goods inventories. Also, materials, followed by work-in-process, are more volatile than finished goods inventories (Ramey, 1989). Therefore, finished goods inventories are typically a relatively small and stable component of working capital.

Economists have long recognized that working capital is a distinct and important part of the firm's stock of capital.[15] Dewing (1941, pp. 706-708), a leading writer in the field of finance during the first part of the twentieth century provides some insights into the role and liquidity of working capital (which he calls "current" capital):

> Every business consists of three elements ... the fixed capital, the current capital, and the organization ... current capital represents the goods acted upon by the permanent capital of the business ... it comprises the raw materials being transformed into finished products by the operations of the business, the finished goods on hand, the credit resulting from the sale of these finished products, and the necessary money to keep the business running smoothly.
>
> Liquidity arises from the fact that the current capital, being consumers' goods, or material easily transformed into consumers' goods, or cash, commands a wider and therefore a quicker market than producers goods. ... Its economic value is direct for the simple reason that current capital may be itself consumed or else easily converted into goods that can be consumed.

Dewing (1941, chapter 7) discusses the essential role of working capital in the production process. He also explains why working capital is a readily reversible capital input. Furthermore, the presence of working capital in a variety of standard "capital ratios" used to measure the financial health of firms attests to its usefulness as a measure of liquidity.[16]

There is also an extensive operations research literature that explains the role of working capital in the production function. Ramey (1989, pp. 340-341) provides an excellent summary of the arguments pertaining to materials and work-in-progress inventories. She notes that uncertainty about materials quality and supply lines causes firms to stockpile materials inventories to reduce the probability of a stockout that would leave workers

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[15] In the *Wealth of Nations* Smith distinguished between circulating and fixed capital. Although not precisely defined, it is clear that his notion of circulating capital is close to the current concept of working capital. See also Marshall (1949).

[16] See, for example, the standard ratios recorded in the Value Line database. We use working capital rather than current assets alone as a measure of reversible assets because current assets cannot be used to raise funds for investment in the short run if they must be used to meet current liabilities.

and fixed capital idle. She also provides several reasons why firms use sizable quantities of work-in-process inventories relative to fixed capital. If firms face large setup costs, for example, they can achieve economies of scale by running large batch sizes. In addition, inventories allow the firm to meet fluctuations in seasonal demand instead of paying overtime wages and maintaining fixed capital used only in peak periods. Trade credit, in the form of accounts receivable, increases output capacity (as well as sales) for two reasons. First, trade credit helps customers to order in large batch sizes and to store output themselves. Second, trade credit facilitates sales to customers who themselves are liquidity constrained.[17]

We assume that firms produce output according to the technology:

$$Y_t = F(W_t, K_t, Z_t)$$

where Y_t represents output, K_t is the stock of fixed capital at the beginning of t, W_t is the beginning-of-period stock of working capital, and Z_t is a vector of variable inputs that play no role in our analysis. We denote investment in fixed capital as I and investment in working capital as ΔW. As in standard neoclassical models, we assume that W and K are complementary inputs and that the first and second partial derivatives of the technology satisfy:

$$\text{(III.1)} \qquad F_W > 0, F_{WW} \leq 0, F_K > 0, F_{KK} < 0, F_{WK} > 0.$$

For normal ranges of working capital, $F_{WW} < 0$, similar to fixed capital. Unlike fixed capital, however, firms may hold working capital in entirely liquid forms such as treasury bills.[18] At high levels of working capital, therefore, we do not rule out the possibility that F_W reaches a lower bound and F_{WW} equals zero. This possibility is not crucial to our argument, but it helps motivate why firms will smooth fixed investment to a greater extent when their balance sheets are strong (W is high).

The firm maximizes the discounted value of cash flows over time subject to the condition imposed by the production function. We assume that the costs of adjusting fixed capital are quadratic in the level of fixed capital investment. For simplicity, we assume that there are no adjustment costs associated with working

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[17] For a general discussion and further references, see Kim and Srinivasen (1988, p. 116).

[18] Typically, cash and equivalents constitutes a relatively small fraction of working capital. Financial analysts emphasize that working capital, not cash on hand, is the most useful measure of a firm's liquidity.

capital. While some working capital adjustment costs may exist, they are presumably small compared to those associated with fixed capital investment. Therefore, the firm's objective function is:

$$\text{(III.2)}\quad \text{Max } V_t = \sum_{j=0}^{\infty} \beta^j \{P_{t+j}\, F(K_{t+j}, W_{t+j}, Z_{t+j}) - P^k_{t+j}\, I_{t+j} - P^w_{t+j}\, \Delta W_{t+j} - (\gamma/2)(I_{t+j})^2\},$$

subject to

$$I_{t+j} = K_{t+j+1} - K_{t+j}$$

$$\Delta W_{t+j} = W_{t+j+1} - W_{t+j}$$

where β is the firm's discount factor, P^k_t and P^w_t are the prices of fixed and working capital, P_t is the price of output, and γ is the fixed capital adjustment cost parameter.[19] All variables dated t+1 and later are expectations. Following Sargent (1979, p. 340), in the absence of financing constraints, the system of first-order conditions for an optimal solution to the problem posed in (III.2) are:

$$\text{(III.3)}\quad \beta P_{t+j+1}\, F_K(K_{t+j+1}, W_{t+j+1}, Z_{t+j+1}) - P^k_{t+j} + \beta\, P^k_{t+j+1} - \gamma I_{t+j} + \beta(\gamma I_{t+j+1}) = 0$$

$$\beta P_{t+j+1}\, F_W(K_{t+j+1}, W_{t+j+1}, Z_{t+j+1}) - P^w_{t+j} + \beta\, P^w_{t+j+1} = 0. \qquad j = 0, \dots, \infty$$

A firm that chooses to expand its output capacity (the kind of firm we study in our empirical tests) will increase K_{t+j} and W_{t+j} ($j = 1, \dots, \infty$) to satisfy these conditions. In perfect capital markets, the limit on the firm's speed of expansion comes from costs of adjustment.

Now, suppose that imperfect capital markets restrict the firm's access to finance. For the sake of clarity, assume for the moment that firms either have no access to external capital or that it is prohibitively expensive. (Alternatively, we could assume that because of credit rationing, all *marginal* finance comes from internal sources.) Therefore,

$$\text{(III.4)}\quad CF_t \geq P^k_t I_t + P^w_t\, \Delta W_t,$$

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[19] To keep the problem simple, we assume no depreciation for fixed or working capital. The discussion that follows also applies in the more general case of geometric depreciation.

where CF_t is the firm's internal cash flow. Because ΔW_t can be negative, that is, investment in working capital is reversible, I_t can exceed CF_t without violating the internal finance constraint.[20]

The existence of the finance constraint may or may not affect the expansion decisions of the firm; it is possible that cash flow is sufficient to prevent equation (III.4) from imposing a binding constraint on the sum fixed and working capital investment. (As argued by FHP (1988), Gilchrist (1989), and Himmelberg (1990), these firms may reveal themselves to the researcher by paying dividends.) If the financing constraint binds, however, the firm will be unable to equate the marginal returns on its investments to zero as in equations (III.3), and it may not be able to equate marginal returns over time. But the existence of a binding financing constraint does not interfere with the firm's ability to equate the marginal returns across alternative investments, net of all adjustment costs, at each point in time. Therefore, even a financially constrained firm should satisfy:

$$\text{(III.5)} \quad \beta P_{t+1} F_K - P^k{}_t + \beta P^k{}_{t+1} - \gamma I_t + \beta(\gamma I_{t+1}) = \beta P_{t+1} F_W - P^w{}_t + \beta P^w{}_{t+1} = \lambda_t$$

where λ_t, the shadow value of additional finance in period t, exceeds one.[21]

Equation (III.5) helps explain how a financially constrained firm optimally responds to a temporary cash flow shock. For example, suppose the firm's output price falls, reducing current cash flow. The firm must decrease total investment to satisfy (III.4). Because of adjustment costs on fixed capital, however, it is unlikely that the firm will cut I and ΔW proportionately. Rather the firm will adjust W more, perhaps even setting ΔW negative. When the firm cuts total investment below its normal level, the marginal products of K and W both rise, given the usual technology assumptions. In addition the marginal adjustment cost for current investment

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[20] While there are ways to include debt finance in the constraint, we will show later in the paper that cash flow is the dominant source of funds the firms in our sample. In general, the predictions of the model would hold up as long as the cost of external finance at the margin exceeds the opportunity cost of internal funds.

[21] In the solution to the dynamic optimization problem (III.2) with the constraint imposed by (III.4), λ_t will depend on the Lagrange multipliers on the finance constraints in both periods t and t+1. The result that λ_t exceeds zero is equivalent to the assumption that the finance constraint holds with equality in period t. There is an applied finance literature that addresses the programming problem of how to allocate working capital when a firm faces financial constraints and variable cash flows. See Charnes, Cooper and Miller (1959) for an early example.

falls (γI_t), while the expected marginal adjustment cost of future investment (γI_{t+1}) rises because future investment is expected to exceed current investment if the shock is temporary. These adjustment cost terms reduce the change in K necessary to establish equation (III.5) for a given change in W. That is, the firm will equate the expected marginal returns from K and W by smoothing I at the expense of ΔW. A symmetric argument applies to positive cash flow shocks. We test several implications of this hypothesis later in the paper.

The model also implies that the degree of investment smoothing depends positively on the initial stock of working capital. Because $F_{WW} \leq 0$, when W is large relative to K the opportunity cost of foregoing a unit of W is relatively small. If W were large enough, even growing firms may find it optimal to set ΔW negative in response to a large negative cash flow shock. But if W is abnormally low relative to K, the optimal degree of fixed investment smoothing will be lower. In this sense, the strength of a firm's "balance sheet" can be important for the link between fixed investment and cash flow.

III.B. Empirical Predictions

This framework leads to four sets of empirical predictions for testing the effect of financing constraints on investment. First, as we demonstrate in the next section, working capital investment is a major use of funds, especially for the growing firms in our sample. If the typical firm requires a significant amount of working capital relative to fixed capital per unit of output, one must account for working capital when formulating hypotheses about the size of cash flow coefficients in reduced-form investment equations. For example, if the production function is Cobb-Douglas with elasticities of 0.6 for fixed capital and 0.4 for working capital, then the cash flow coefficient in a fixed investment regression should not exceed 0.6 (as opposed to unity), even for a firm that relies entirely on internal finance for its expansion.

Second, even if firms face financial constraints, they may still exhibit lower variance in fixed investment than in cash flow because they smooth fixed investment with changes in working capital. We predict that $\sigma^2(I) < \sigma^2(CF)$. If working capital is the key internal source of liquidity that firms use to smooth fixed investment, we predict that $\sigma^2(\Delta W) > \sigma^2(CF)$.[22] With volatile cash flow, ΔW may frequently be negative, even for growing firms. An alternative explanation for negative ΔW is that firms issue new shares in "bunches" to reduce transactions costs, put the proceeds into working capital, and draw down working capital over time to finance fixed investment. We will show later, however, that this explanation is inconsistent with the evidence from our sample (see footnote 31).

Third, the standard "within-firm" estimator (used to control for unobservable firm-specific effects in this literature) may underestimate the full effect of internal finance on fixed investment. This idea is explained more fully in the next section. Basically, the within-firm estimator captures only the intra-firm relation between fixed investment and cash flow, that may be dampened if the firm uses working capital to smooth temporary cash flow shocks. Therefore, even if the firm is completely constrained to finance its growth with internal funds, the regression coefficient on cash flow estimated from specifications commonly employed in the literature could be small, depending on the initial stock of working capital. For this reason, the estimates of internal finance effects presented in the existing literature may be interpreted as the average "short-run" or "temporary" effect; that is, they reflect the impact of cash flow on fixed investment net of smoothing behavior.[23] One way to estimate the "long-run" effect of cash flow on fixed investment is to include (endogenous) changes in working capital in the regression. We predict that this change in specification will increase the cash flow coefficient compared with a specification that does not account for investment smoothing. Because a reduction of working capital will allow an increase in fixed investment and vice-versa, we predict that the coefficient on the change in working capital will be negative in a fixed investment regression for financially-constrained firms.

Finally, the addition of ΔW to the standard investment equation used in this literature can go a long way toward resolving a long-standing debate about the correct interpretation of the cash flow effect on investment. The view that competes with the financial constraint interpretation is that cash flow simply captures new information about the profitability of fixed investment not reflected by the other variables in the regression. In this case, however, one would expect ΔW to either have no effect on fixed investment, or, because it may also

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[22] These results also clearly imply that $\sigma^2(\Delta W) > \sigma^2(I)$, which may arise even in the absence of financial constraints because of lower adjustment costs for working capital. See Chirinko (1990) for further discussion.

[23] Himmelberg and Petersen (1989) make similar arguments for R&D expenditures.

include some information about future profits from fixed capital, ΔW may even have a positive coefficient. Furthermore, for similar reasons, including ΔW would probably reduce the cash flow coefficient. These predictions are the opposite of what our financial constraint - investment smoothing model predicts. Therefore, our econometric evidence provides a direct way of distinguishing between these competing explanations for the observed positive relation between cash flow and investment.

IV. Data Sample

Our data are taken from the Value Line database of financial market, balance sheet, and income statement information for a panel of U.S. manufacturing firms (two-digit SIC codes between 20 and 39). Variable definitions are given in the data appendix. We are interested in the behavior of firms that are especially likely to face binding financial constraints at the margin, therefore we focus on firms that pay essentially no dividends. The logic of this selection criterion is straightforward. In a world of perfect capital markets, dividend behavior should reveal nothing about investment behavior. However, when firms face credit rationing and high lemons premia for new equity finance, firms that exhaust all internal finance are likely to face a binding finance constraint.[24] Gilchrist (1989) has shown that the Euler equation that would hold in perfect capital markets is rejected for zero-dividend firms, providing formal statistical support for this selection criterion.

The choice of the time period for our analysis reconciles two competing objectives. We would like to use as many years as possible to increase the time-series variation of the data and provide the most efficient estimates. If we use too long of a panel, however, the characteristics of the firms in the sample may change. In particular, we are concerned with the maturation of firms that are initially financially constrained. The data collection procedure used by Value Line helps address the maturation problem. Firms are added to the sample when they become of sufficient interest to Value Line's customers to justify the cost of maintaining their data.

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[24] To maintain comparability to earlier research, the sample and dividend selection criterion we used are the same as in FHP (1988). Firms are chosen for the sample if they have dividend to income ratios below ten percent for at least ten of the fifteen years between 1970 and 1984. See FHP for further details.

But at the time a firm is added to the database, its historical financial data is also added, going back as far as possible. Therefore, the database contains information on firms before they were of sufficient size and interest to be included in the Value Line sample. Most of the firms in our sample had not been added to the database before 1980 (see FHP, 1988 for further details). These firms also paid virtually no dividends during this period, while many of these firms began to pay some dividends in the 1980s. For these reasons, we have reported results for the decade of the 1970s.[25]

The key summary statistics for our sample of 48 firms are given in Table 1. Because of skewed distributions for these variables, we have reported both mean and median values. The firms are relatively small. The median values of their fixed and working capital stocks in 1970, the beginning of our sample, was $19.3 million and $14.1 million, respectively (in 1982 dollars). On average, these firms grew rapidly over the sample period. The annualized (real) growth rate of median fixed capital was 10.2 percent while median working capital grew at an 11.3 percent rate. The large size of working capital relative to fixed capital is consistent with our view that working capital is a key input in the production process. The nearly equal growth rates of the two inputs indicate an approximately homogeneous production technology. The data also clearly show that changes in working capital constitute a major portion of total investment.

The second part of Table 1 provides data on the sources of funds for these firms. Internally generated cash flow is the primary source of funds, accounting for over 71 percent of total funds. Debt contributed 17 percent of total funds, with 12 percent coming from new share issues. The average new share issue figure is misleading, however, because it is skewed by a small number of large issues. The median value of new share issues is virtually zero. Even the 75th percentile is less than 5 percent of total sources of funds. The typical firm in our sample obtains the great majority of its funds internally while using a modest amount of debt. In a world of credit rationing, these numbers are consistent with the view that these firms rely almost completely on internal finance at the margin.

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[25] We considered the results from a variety of other sample periods. For samples as short as five years, the results were more variable, but qualitatively consistent with those reported below. The results for the full FHP sample of 1970-84 were quite strong, and consistent with the results reported here. The results also did not change substantially if the selection criterion for zero-dividend firms was based on 1970 through 1979 only.

V. EMPIRICAL EVIDENCE

V.A. Variance Tests of Investment Smoothing

One test of investment smoothing for financially constrained firms is analogous to the tests of production smoothing presented by Blinder (1986) based on the identity:

(V.1) $$Y_t = S_t + (INV_t - INV_{t-1})$$

where Y_t is output in year t, S_t is sales in t, and INV_t is the stock of inventories at the end of period t. To test for production smoothing relative to sales, one checks whether the variance of production is less than the variance of sales. Furthermore, because inventories constitute the buffer stock that allows smoothing, the change in inventories should have a negative covariance with sales.

To develop the analogous case for investment smoothing under financial constraints, suppose that firms only obtain funds at the margin from internal sources, and that these funds are used exclusively to finance fixed or working capital accumulation. Then, as explained in section III, the sources and uses of funds relation can be written as:

(V.2) $$I_t = CF_t - \Delta W_t$$

where I_t is fixed investment in year t, CF_t is internal cash flow in t, and ΔW_t is the change in the stock of working capital during period t.[26] Equation (V.2) is similar to the production smoothing identity (V.1). Firms use the stock of working capital to smooth investment relative to variations in cash flow. Note that the existence of financial constraints arising from imperfect capital markets is crucial to the logic of this argument. A firm that can obtain external finance on essentially the same terms as its opportunity cost of internal funds may want to smooth investment relative to cash flow, but it need not use working capital to accomplish such smoothing.

In practice, the firms in our sample have obtained limited amounts of external finance and may have other uses for their funds besides the accumulation of fixed and working capital. Therefore, equation (V.2) will only approximate the linkages between investment, cash flow, and changes in liquidity. Nevertheless, this

[26] Cash flow is defined as after-tax income plus non-cash expenses, chiefly depreciation and amortization. As mentioned before, working capital is defined by Value Line as the difference between current assets and current liabilities.

analogy motivates some simple tests of the joint hypotheses of financial constraints and investment smoothing. As a first step, we compare the variance of investment to the variance of cash flow. These statistics are reported in Table 2. We have scaled all the variables by the stock of fixed capital to control for changes in the size of the firms. So that the variance and covariance measures are not affected by differences in the ratios across firms, the statistics in Table 2 are computed after subtracting the firm mean from each observation. The statistics provide some evidence of investment smoothing relative to cash flow. The variance of the cash flow-to-capital ratio is about 42 percent higher than the variance of the investment-to-capital ratio. Furthermore, the correlation between the change in working capital and cash flow is strongly positive. When cash flow is low, working capital is reduced, consistent with the hypothesis that working capital functions as a buffer stock. Finally, the variance of the change in working capital, that is, the variance of working capital investment, is almost 4 times greater than the variance of fixed investment, again consistent with the hypothesis that firms use working capital as a source of liquidity to smooth fixed investment.

As mentioned previously, it is possible that our sample firms smooth investment through external finance, either new debt or equity. But aside from a few outliers, the value of new equity issues is very small. These firms appear to have some access to debt, but as Table 2 shows, the correlation of changes in debt with cash flow is *positive*. Therefore, new debt tends to reinforce rather than offset cash flow fluctuations, on average, consistent with credit rationing at the margin.

Finally, the empirical distribution of $\Delta W/K$ provides evidence that working capital is used for smoothing. As the summary statistics in Table 1 show, the firms in our sample grew very quickly, in terms of both output and capital. Yet, as the last row of Table 2 shows, the change in working capital was negative in *over 21 percent* of our observations. In contrast, cash flow was negative in less than 6 percent of the observations. If these fast-growing firms were able to easily obtain external finance, it is hard to imagine why they would *reduce* the absolute level of working capital so often. On the other hand, frequent negative changes in working capital would be expected if firms use this relatively liquid asset to smooth fixed capital investment.

V.B. Working Capital and Smoothing Effects in the Investment Equation

Many recent studies have examined the effect of internal finance on fixed investment use an equation similar to:

(V.3) $$(I/K)_{jt} = A_1(q_{jt}) + A_2(CF/K)_{jt} + A_j + A_t + u_{jt}.$$

The variable I_{jt} represents plant and equipment investment for firm j at time t. The tax-adjusted measure of Tobin's q at the beginning of year t (q_{jt}) controls for changes in investment demand.[27] Investment and cash flow are scaled by the firm's beginning-of-period capital stock. The intercept coefficients, A_j and A_t allow for firm-specific effects (a "fixed effects" model) and year effects; u_{jt} is a random error term.

It is likely that the individual firm effect (A_j) is correlated with cash flow, perhaps because of differences in managerial ability or the kind of capital the firm uses. With panel data, the standard practice in this literature has been to control for unobservable fixed effects by subtracting the firm-specific mean of each variable from each observation before running regressions. This "within-firm" estimator sweeps out the influences of differences in average levels of the regressors across firms. In particular, any relation between firms' average fixed investment and average cash flow will not affect the cash flow coefficient estimate.

As we have argued, use of this technique causes a possibly serious problem with estimating equation (V.3) because the results may measure only the short-run effect of financing constraints on investment. If firms smooth fixed investment around their average I/K ratio because of adjustment costs, the within-firm relationship between fixed investment and cash flow may appear quite weak. Yet the firm could still rely almost entirely on cash flow to finance its average level of investment, a relationship which is discarded in the effort to control for the problem of unobservable fixed firm effects.

To account for smoothing, while still controlling for firm-specific effects, we include ΔW in the regression, as suggested by the analysis in section III. Note that ΔW is dimensionally equivalent to cash flow, but it can be a net *use or source* of funds since firms can readily choose to expand or contract the stock of working capital. Our basic empirical investment equation is:

[27] Our definitions of tax-adjusted q and the replacement value of the capital stock measure used throughout the paper are based on Salinger and Summers (1983). See the data appendix for details.

(V.4) $(I/K)_{jt} = A_1(q_{jt}) + A_2(CF/K)_{jt} + A_3(\Delta W/K)_{jt} + A_j + A_t + u_{jt}.$

We will also consider the effect of introducing other variables that affect investment demand, particularly output or sales.

In estimating equation (V.4), we must account for the fundamental endogeneity of changes in working capital (ΔW_{jt}), a decision variable in our model from section III. This endogeneity may result in correlation between disturbances to investment and changes in working capital. For this reason, we estimate various forms of equation (V.4) with instrumental variables. The instruments are beginning-of-period q, cash flow, the beginning-of-period stock of working capital divided by fixed capital, $(W/K)_{jt}$, and the fixed time and firm effects.[28] The choice of the $(W/K)_{jt}$ instrument, which identifies equation (V.4), follows directly from the smoothing model discussed in section III. If the firm begins the period with a low stock of working capital relative to fixed capital, then the marginal product of working capital is large, and the firm will find it optimal to set ΔW at higher than normal levels, if possible. A symmetric argument shows that a high working capital stock will be associated with low, possibly negative ΔW. Because of this relationship, and the fact that the stock of working capital is measured at the beginning of the period, it is an ideal instrument.

The first stage OLS regression from our instrumental variables procedure supports this interpretation of the role played by the instruments:

$$(\Delta W/K)_{jt} = A_j + A_t \underset{(3.5)}{+ 0.0064\,(q_{jt})} \underset{(12.1)}{+ 0.883\,(CF/K)_{jt}} \underset{(5.1)}{- 0.217\,(W/K)_{jt}}.$$

The fixed effects are not reported and t-statistics appear below the estimated coefficients. The strong cash flow effect and the negative coefficient on the beginning-of-period stock of working capital are completely consistent with our predictions from section III. This equation functions much like a modified stock adjustment model for working capital. For panel data, this instrumental variables regression also provides a relatively good fit for the

[28] Cash flow may also have some degree of endogeneity because if firms reduce working capital to smooth fixed investment, current costs rise and cash flow falls. Observed cash flow changes may exceed exogenous variations in cash flow, therefore, biasing the cash flow coefficient toward zero. We find some support for this view in that treating cash flow as endogenous increases its estimated coefficient. This result is not reliable, however, because it is difficult to find good instruments for the idiosyncratic variations in current cash flow that should be of fundamental importance for investment in firms that face financial constraints.

endogenous change in working capital. The adjusted R^2 is 0.36 in this first-stage regression with all variables expressed as deviations from their firm means, thereby excluding the explanatory power of the firm fixed effects.

Estimates of both (V.3) and (V.4) appear in Table 3. Equation (3.1) includes only q, cash flow, and the fixed effects, the standard regression that many recent papers use to test for the importance of internal finance constraints on investment. Our results are consistent with other findings of statistically and economically significant coefficients on cash flow in a q investment equation. The estimated cash flow coefficient in equation (3.1) is similar to those reported by previous studies. As argued in section III, however, this kind of regression is likely to capture only the short-run impact of cash flow shocks on investment. If fixed investment smoothing is important, it understates the full impact of internal finance for financially constrained firms. In equation (3.2) we add the (endogenous) change in working capital to the specification of equation (3.1) and estimate the coefficients with instrumental variables as described above. The results are striking. The change in working capital has the expected negative coefficient and is significantly different from zero. The cash flow coefficient nearly doubles, consistent with our previous discussion.[29]

These results provide stronger evidence for the importance of internal finance for investment than the basic link between investment and cash flow, evident in equation (3.1). The positive relation between investment and cash flow has been interpreted as evidence of misspecification of the investment equation. If this were the case, cash flow could proxy variations in profits that are not adequately captured by q or other variables in the equation. Results such as those reported in equation (3.1) might be viewed as an empirical failure of standard investment demand models rather than evidence for the existence of financial constraints.[30]

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[29] An alternative to the commonly used fixed-effects estimator is to estimate the equation in first differences. Our results with first differences are qualitatively consistent with those reported in equation (3.2), the cash flow coefficient rises substantially when ΔW is added to the regression and the ΔW coefficient is negative and quite significant. The size of the coefficients is somewhat smaller (0.536 for CF, -0.216 for ΔW). The most likely explanation for this change is measurement error. Grilliches and Hausman (1986) show that the first-difference estimator is more sensitive to measurement error, causing downward bias in the estimates relative to the fixed-effect, within-firm estimator.

[30] See the comments of Poterba (1988, p. 202). Jorgenson (1971) interprets the significance of cash flow or profits in an investment equation as a proxy for output effects, an issue we take up later. Abel and Blanchard (1986) find a residual role for profits (as well as output) indicating possible mis-specification in q equations. Hubbard and Kashyap (1990) also emphasize the ambiguous interpretation of cash flow effects in empirical investment equations.

But this misspecification interpretation is not consistent with the results in equation (3.2). Changes in working capital are positively correlated with profits, output, and the business cycle. If the ΔW variable in equation (3.2) proxied some kind of omitted "accelerator effect," *its estimated coefficient would be positive and it should reduce the effect of cash flow* when compared with the results from a specification like equation (3.1). The actual results are just the opposite of these predictions, consistent with the joint hypotheses of investment smoothing and the existence of financial constraints.[31]

The cash flow coefficient in equation (3.2) can be interpreted as the effect on fixed investment of changing the *flow* of internal finance holding the *stock* of working capital constant. Of course, there is no reason to assume in general that working capital will not change. Therefore, the quantitative impact of cash flow shocks on investment depends on the particular conditions the firm faces when the shocks occur, especially the condition of their balance sheets. If a negative cash flow shock occurs at a time when firms have strong balance sheets and an abundance of working capital, ΔW will be smaller than normal, even negative, to smooth the impact of low cash flow on investment. The same cash flow shock when the firm is illiquid, after a downturn in the business cycle for example, will have a bigger impact on fixed investment. With low working capital the firm's opportunity cost of sacrificing working capital investment to smooth fixed investment will be high.[32] Therefore, these results show that the link between cash flow and investment can be much more complex than it appears in most of the existing literature.

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[31] Another possible explanation for the negative coefficient on ΔW is that high transaction costs of external finance, especially new share issues, cause firms to issue them infrequently, storing the proceeds in working capital until they are needed for investment. This phenomenon is unlikely to explain our results, however. First, we have shown that the firms in our sample make little use of external finance, especially new share issues. Second, the sample correlation between fixed investment and changes in working capital is positive, not negative as the "bunching" of new equity issues would imply. Finally, we split the sample on the median usage of new equity finance and re-estimated the regressions. The ΔW coefficients remained negative and significant in both halves of the sample, but the coefficient for firms in lower half of the new equity distribution was substantially *larger* than for the firms that used a greater amount of new equity, again inconsistent with the bunching explanation. We thank Ben Bernanke and Charles Himmelberg for helpful comments on this issue.

[32] This point is made by Gertler and Hubbard (1989). They find empirical support for the proposition that cash flow shocks matter more for investment during downturns of the business cycle.

A full treatment of the long-run impact of cash flow on fixed investment would require estimation of a structural equation for the change in working capital, which is beyond the scope of this paper.[33] Under some simplifying assumptions that are consistent with our estimates, however, we can gain additional structural information from our equation. The summary statistics in Table 1 show that the firms in our sample make little use of new debt or equity, especially at the median values. Suppose that these firms use each dollar of cash flow exclusively for fixed or working capital investment and that they do not have alternative sources of funds at the margin. Using the sample median values to approximate the long-run ratio of fixed to working capital investment would imply that about 60 percent of each dollar of cash flow would go to fixed investment, with the remaining 40 percent allocated to working capital. We can use the estimates of equation (3.2) to test the consistency of this interpretation. The long-run effect of changes in cash flow on working capital would be 0.40. Therefore, equation (3.2) in table 3 predicts the long-run effect of changes in cash flow on fixed investment as 0.743 - 0.430 (0.40) = 0.571. This result is remarkably close to the mean value of the input share for fixed capital (0.60) calculated from table 1. The results are even closer if one uses the sample means rather than medians. This calculation demonstrates two important points. First, it shows that the long-run impact of cash flow on fixed investment can be much larger than conventionally estimated. Second, these results are consistent with the view that firms such as those in our sample are completely dependent on internal finance for their *total* growth, including both fixed and working capital.

To further investigate this point, we defined total investment as the sum of fixed and working capital investment. For this measure of total investment, the firm no longer has any obvious means of smoothing. We regressed this composite investment variable on q, cash flow, and fixed effects for each firm and each year, using ordinary least squares. We obtained a cash flow coefficient quite close to unity (1.221 with a standard error of 0.083). If we include sales and lagged sales in the model (see the discussion in the next section) the cash flow coefficient is 0.975 with a standard error of 0.102. These results corroborate the point that the long-

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[33] The key problem is finding an appropriate instrument to identify the working capital equation. The stock of fixed capital would be the obvious choice, analogous to the approach used for the fixed capital equation. But this variable is used to scale the data, maintaining comparability of our results to the rest of the literature.

run effect of financing constraints on total investment is much larger than the findings reported in previous studies suggest. It appears that the effect of internal finance on total investment can be virtually dollar-for-dollar.

V.C. Alternative Specifications and Robustness

The basic econometric results of this paper appear in Table 3. We have found these results to be remarkably robust to alternative specifications and changes in estimation technique. This section summarizes these results.

In spite of the well-developed microfoundations for the q theory of investment demand, its empirical performance has been criticized from a variety of perspectives. One significant problem is that output or sales variables typically have explanatory power for investment in q equations (see Abel and Blanchard, 1986, for example). The strong effect of sales can be motivated by traditional "accelerator" ideas (see Eisner, 1978). More recently, the importance of sales for investment has been explained by imperfect competition. Regardless of the microeconomic motivation for including sales in investment equations, it is interesting to consider whether the conclusions reached above regarding the empirical importance of investment smoothing for the evaluation of financial constraints hold up in equations that include sales variables.

The results in Table 4 show the effect of adding contemporaneous and lagged sales-to-capital ratios to the basic model. The estimated coefficients on the sales variables are quite significant. Including sales reduces the quantitative effect of the internal finance variables, cash flow and the change in working capital, compared with the basic model estimates from Table 3. This change is not surprising given the collinearity of cash flow and sales. The coefficients still remain significant, however, both statistically and economically.

Most importantly, the addition of the change in working capital in equation (3.2) has the same qualitative effect on the cash flow coefficient that we observed earlier in models that excluded the sales variables: the effect of changes in working capital is negative, and the marginal impact of cash flow is substantially larger in the regression including the change in working capital. This test provides further evidence that the effect of working capital in these regressions is not simply a proxy for some kind of omitted accelerator effect; the financial constraint interpretation holds up well when sales variables are included directly in the model.

We also added lagged investment to the model (with and without sales) as suggested by Devereux and Schianterelli (1989) and Gilchrist (1989). The lagged investment term was statistically significant, but the other coefficients were virtually unchanged in these regressions. Without sales, the CF and ΔW coefficients were 0.709 and -0.388, respectively; with sales and lagged sales in the model these coefficients were 0.389 and -0.213.

As we discussed previously, the interpretation of cash flow coefficients in investment equations has been clouded by the question of whether cash flow effects indicated financial constraints or signals of future profitability not captured by other variables. The interpretation of our results for cash flow and the change in working capital seem inconsistent with the profit signal explanation for reasons discussed above. Nevertheless, we included end-of-period q in the regressions to capture any "news" about the firms' prospects that may arise during the year. The results presented in Table 5 show that this change has very little effect on the results; the impact of adding changes in working capital to the regression are almost the same as in the basic model. If sales variables are included in the regression with end-of-period q, the results are virtually identical to those presented in Table 4.

As a final test of the robustness of our results, we estimated our equations with the sample of high-dividend firms from FHP (1988). Table 6 presents results for firms that pay more than 20 percent of their income as dividends in most years (see FHP, 1988 for details). In the regressions that exclude sales variables, cash flow has a significant impact on investment. Furthermore, the change in working capital has a negative estimated coefficient, and adding the change in working capital to the regression increases the cash flow coefficient, consistent with the financial constraint / investment smoothing model. As emphasized by FHP (1988), however, the cash flow coefficient is much smaller than the corresponding effect estimated for zero-dividend firms (see Table 3). The estimated coefficient on the change in working capital is also much smaller for high-dividend firms, and its inclusion has a smaller impact on the cash flow coefficient. When the sales variables are included, the results are even more striking. While the signs of the coefficients on the internal finance variables are still consistent with the existence of financial constraints and investment smoothing, the magnitude of the coefficients is quite small, only about one-fifth to one-sixth the values for low-dividend firms in the corresponding specification that includes sales variables.

These results provide some evidence that the large, high-dividend firms from the FHP sample experience financial constraints on investment spending. But, as one would expect, the size of these effects is much smaller than for zero-dividend firms. The results in Table 6 must be interpreted with caution, however. To explain why investment would be financially constrained at the margin for such firms, one must explain why they cut investment rather than dividends when cash flow declines. If changes in dividends provide signals about future profits, this kind of behavior may be optimal, but we do not pursue this question further here. Also, while the cash flow and liquidity variables remain statistically significant in the regression with sales, their estimated coefficients are quite small. For our purposes, however, the interesting point is that the differential effect of internal finance and liquidity on investment between the high and low dividend samples provides further support for the hypothesis that financial constraints and investment smoothing are at the root of the results for the zero-dividend firms we focus on in this paper.

IV. Conclusion

The investment behavior of firms that may face financial constraints has come under close scrutiny in many recent studies. The results strongly suggest that at least some firms face binding internal finance constraints, especially those that pay low or zero dividends. Measuring the economic importance of financing constraints, however, remains an unresolved issue. Moreover, it is an issue that economists should care about, as a substantial proportion of publicly-traded companies in the United States do not pay dividends at any point in time. Furthermore, one would expect financial constraints to be an even greater problem for the typical private firm.

In this paper, we tackle this problem by explicitly considering two important aspects of investment behavior that the recent literature largely ignores: firms' incentives to smooth fixed investment because of adjustment costs and the key role of working capital in the production process. An important property of working capital is its reversibility. Therefore, if smoothing incentives are strong enough, firms that face binding constraints on total investment may nevertheless smooth the path of fixed investment by adjusting working capital to an extent that depends on the strength of firms' balance sheets. This results implies that previous attempts to estimate the impact of cash flow on fixed investment looking only at intra-firm movements of investment and cash flow may have identified only the "short-run" impact of financing constraints.

Incorporating changes in working capital in a fixed investment equation also helps resolve the debate in the literature about whether cash flow effects on fixed investment represent binding finance constraints or simply proxy changes in expected profits. If the profit signal story explains the empirical role for internal finance in investment equations, then the change in working capital, another potential signal of expected profits, should enter with a positive sign and reduce the estimated effect of cash flow. The financial constraint / investment smoothing explanation we propose, however, has just the opposite empirical prediction. There is no identification problem.

Our findings strongly suggest that zero-dividend firms smooth fixed investment with working capital. Working capital investment is much more variable than movements in cash flow, which in turn is more variable than movements in the rate of fixed investment. More importantly, we find that the measured effect of cash flow on fixed investment is much larger once we control for movements in working capital. Our results suggest that changes in internal finance may have close to a dollar-for-dollar effect on the total capital investment of the firm. In addition, the negative coefficient on changes in working capital clarifies the role of liquidity (both cash flow and the stock of working capital) in reduced-form regressions. This result clearly supports the financial constraint interpretation of the impact of internal finance, as opposed to the view that internal finance variables just proxy changes in investment demand not captured by the other variables in the equation.

These results have important implications for research in both industrial organization and macroeconomics. In industrial organization, economically large effects of financial constraints on investment provide the foundation for claims that differential access among firms to capital markets result in barriers to entry.[34] Our results also provide support for strategic models of firm behavior based on the assumption that some competitors must rely on internal finance for expansion. This behavior includes predatory pricing

[34] See Bain's (1956) original discussion of this issue.

(Fudenberg and Tirole, 1986, for example) and dynamic limit pricing (Judd and Petersen, 1986). In addition, our results support theories of conglomerate mergers based on differential access to capital markets.

From a macroeconomic perspective, fluctuations of investment account for a substantial portion of the movements in GNP.[35] It is also well known that profits are volatile over the business cycle. The link between internal finance and investment, therefore, can help explain an important feature of output fluctuations. Our results go further, however, because they tie the magnitude of investment fluctuations induced by cyclical changes in internal finance to the strength of firm's balance sheets. If firms are highly liquid, they will be able to smooth fixed investment relative to fluctuations in cash flow without the need for costly external funds. But a severe downturn that weakens balance sheets, or a wave of corporate restructuring that reduces liquidity, may make investment much more susceptible to recession and declining internal finance than most estimates of "cash flow effects" in previous studies imply. This point provides empirical support for recent models of business cycles that emphasize fluctuations of "internal net worth" as a key factor in propagating, magnifying and even causing cyclical fluctuations.[36]

Finally, these results may help explain cyclical fluctuations of inventories, long recognized as a major part of the business cycle. Because inventories, particularly materials and work-in-process, constitute part of working capital, our results predict that they will vary procyclically as financially-constrained firms smooth fixed investment relative to variations in profits. Such behavior may help explain Ramey's (1989) findings of large "unobserved shocks" to inventory demand during recessions, which she suggests may arise from capital market imperfections, consistent with our findings here. Furthermore, our approach implies that these demand shifts may be explained as the endogenous outcome of investment smoothing when firms face financial constraints, rather than exogenous "shocks."

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[35] Barro (1987) concludes that 88 percent of the shortfall in GNP during recessions is due to declines in all categories of investment expenditures.

[36] See, in particular, Bernanke and Gertler (1989) and empirical studies by Gertler and Hubbard (1988) and Hubbard and Kashyap (1990). Although this idea has resurfaced in the literature only recently, its roots go back a long way. Gurley and Shaw's (1955) concept of "financial capacity" is related to the liquidity and balance effects we study here. Minsky (1975) emphasizes that the process of financing investment during a boom systematically weakens balance sheets, making the effects of a later downturn more severe.

DATA APPENDIX

The data used for this study were drawn from the sample developed by FHP (1988). A brief description follows; for further details see FHP (pp. 191-195).

As explained in the text, our primary interest is in firms that pay low dividends. All the statistics reported in this paper, with the exception of Table 6, are based on firms in the Value Line database that paid less than 10 percent of their income as dividends in at least 10 years from 1970-84 (class 1 firms in FHP). As indicated in the paper, the results we obtain are quite similar if we select low dividend firms based on their behavior over the 1970-79 period alone. Therefore, we used the FHP class 1 sample to maintain comparability with earlier work. We excluded one firm from the FHP sample because of its unrealistic Tobin's q values early in the sample.

Q definition: Our Q variable is adjusted for corporate taxation. It is defined as:

$$Q = (1 - \tau)^{-1} \{(V + B - X - N)/K - (1 - k - \tau z)\}$$

where V is the market value of equity, B is the book value of total debt, X is the present value of tax deductions from existing capital, N is an estimate of the market value of inventories, and K is an estimate of the replacement value of the capital stock. The investment tax credit rate is denoted by k, z is the expected present value of future depreciation deductions per dollar of investment, and τ is the corporate income tax rate. A variety of definitions of Q were used in the FHP study (including changes in the tax adjustments and estimates of the market value of debt) with little impact on the results.

Replacement Value of the Capital Stock: Book values of fixed capital were adjusted for depreciation and inflation using the method developed by Salinger and Summers (1983).

Cash Flow: Cash flow is after-tax income plus all non-cash charges to income (primarily depreciation and amortization). We do not subtract dividends from cash flow.

Working Capital: Current assets (assets expected to be converted into cash, sold, or consumed in the normal course of business, including accounts receivable, inventories and cash and marketable securities) less current liabilities (obligations due in a year or less).

Sales: Gross revenue less returns, discounts and allowances.

REFERENCES

Abel, Andrew B. *Investment and the Value of Capital*, New York: Garland Publishing Company, 1979.

______ and Olivier Blanchard. "The Present Value of Profits and Cyclical Movements in Investments," *Econometrica*, volume 54 (1986), pp. 249-273.

Akerlof, George A. "The Market for 'Lemons': Qualitative Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, vol. 84 (August 1970), pp. 488-500.

Bain, Joe S. *Barriers to New Competition*, Cambridge, Massachusetts: Harvard University Press, 1956.

Barro, Robert J. *Macroeconomics*, New York: John Wiley and Sons, 1987.

Bernanke, Ben S. and Mark Gertler. "Agency Costs, Net Worth and Business Fluctuations," *American Economic Review*, volume 79 (1989), pp. 14-31.

Blinder, Alan S. "Can the Production Smoothing Model of Inventory Behavior Be Saved?" *Quarterly Journal of Economics*, volume 101, number 3 (August, 1986), pp. 431-453.

______. "Comments on Fazzari, Hubbard and Petersen," *Brookings Papers on Economic Activity*, 1:1988, pp. 196-200.

Calomiris, Charles W. and R. Glenn Hubbard. "Firm Heterogeneity, Internal Finance, and Credit Rationing," *Economic Journal*, volume 100 (March 1990).

Charnes, A., W.W. Cooper and M.H. Miller. "Applications of Linear Programming to Financial Budgeting and the Costing of Funds," *Journal of Business*, volume 32 (1959).

Chirinko, Robert S. "Tobin's Q and Financial Policy," *Journal of Monetary Economics,* volume 19 (1987), pp. 69-87.

______. "Investment, Tobin's Q and Multiple Capital Inputs," University of Chicago, 1989.

Devereux, Michael and Fabio Schianterelli. "Investment, Financial Factors and Cash Flow: Evidence from U.K. Panel Data," 1989.

Dewing, Arthur Stone. *The Financial Policy of Corporations*, fourth edition, New York: The Ronald Press Company, 1941.

Eisner, Robert. *Factors in Business Investment*, Cambridge, Massachusetts: Ballinger, 1978.

______ and Robert H. Strotz. "The Determinants of Business Investment," in the Commission on Money and Credit Impacts of Monetary Policy, Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1983.

Fazzari, Steven M. and Michael Athey. "Asymmetric Information, Financing Constraints, and Investment," *Review of Economics and Statistics*, volume 69, number 3 (August, 1987), pp. 481-487.

Fazzari, Steven M., R. Glenn Hubbard, and Bruce C. Petersen, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, 1:1988, pp. 141-195.

Fudenberg, Drew and Jean Tirole. "A Theory of Exit in Duopoly," *Econometrica*, volume 54 (1986), pp. 943-960.

Gertler, Mark. "Financial Structure and Aggregate Economic Activity: An Overview," *Journal of Money, Credit and Banking*, (August, 1988).

______ and R. Glenn Hubbard. "Financial Factors and Business Fluctuations," Federal Reserve Bank of Kansas City, (August, 1988).

Gilchrist, Simon. "An Empirical Analysis of Corporate Investment and Financing Hierarchies Using Firm Level Panel Data," University of Wisconsin, 1989.

Greenwald, Bruce C. and Joseph E. Stiglitz. "Macroeconomic Models with Equity and Credit Rationing," forthcoming in R. Glenn Hubbard, ed. *Asymmetric Information, Corporate Finance and Investment*, University of Chicago Press, 1990 (forthcoming).

Grilliches, Zvi and Jerry Hausman. "Errors in Variables in Panel Data," *Journal of Econometrics*, volume 31 (1986), pp. 93-118.

Gurley, John and Edward Shaw. "Financial Aspects of Economic Development," *American Economic Review*, volume 45 (1955), pp. 515-38.

Hall, Robert E. "Stochastic Implications of the Life-Cycle Permanent Income Hypothesis: Theory and Evidence," *Journal of Political Economy*, volume 86, no. 6 (1978), pp. 501-517.

Hayashi, Fumio. "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, volume 50 (January, 1982), pp. 213-224.

______. "Tests for Liquidity Constraints: A Critical Survey and Some New Observations," in Truman F. Bewley *Advances in Econometrics*, Cambridge University Press, 1987.

Himmelberg, Charles. "A Dynamic Analysis of Dividend and Investment Behavior," Northwestern University, 1990.

______ and Bruce C. Petersen. "R&D and Internal Finance: A Panel Study of Small Firms in High-Tech Industries," Federal Reserve Bank of Chicago, 1989.

Holt, Charles C., Franco Modigliani, John F. Muth and Herbert A. Simon. *Planning Production, Inventories and Work Force*, Englewood Cliffs, New Jersey: Prentice-Hall, 1960.

Hubbard, R. Glenn and Anil Kashyap. "Internal Net Worth and the Investment Process: An Application to U.S. Agriculture," Columbia University, 1990.

Hoshi, Takeo, Anil Kashyap and David Scharfstein. "Corporate Structure and Investment: Evidence from Japanese Panel Data," *Quarterly Journal of Economics*, forthcoming.

Jorgenson, Dale W. "Econometric Studies of Investment Behavior: A Survey," *Journal of Economic Literature*, vol. 9 (December 1971), pp. 1111-1147.

Judd, Kenneth L. and Bruce C. Petersen. "Dynamic Limit Pricing and Internal Finance," *Journal of Economic Theory*, volume 39 (1986), pp. 368-399.

Lucas, Robert. "Adjustment Costs and the Theory of Supply," *Journal of Political Economy*, volume 75 (1967), pp. 321-334..

Marshall, Alfred. *Principles on Economics,* New York: Macmillan, 1949.

Meyer, John and Edwin Kuh. *The Investment Decision*, Cambridge, Massachusetts: Harvard University Press, 1957.

Minsky, Hyman P. *John Maynard Keynes*, New York: Columbia University Press, 1975.

Myers, Stewart C. "The Capital Structure Puzzle," *Journal of Finance*, volume 39 (May 1984), pp. 575-592.

______ and Nicholas S. Majluf. "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have," Journal of Financial Economics, vol. 13 (June 1984), pp. 187-221.

Oliner, Stephen and Glenn D. Rudebusch. "Internal Finance and Investment: Testing the Role of Asymmetric Information and Agency Costs," Board of Governors of the Federal Reserve, 1989.

Poterba, James. "Comments on Fazzari, Hubbard and Petersen," *Brookings Papers on Economic Activity*, 1:1988, pp. 200-204.

Ramey, Valerie. "Inventories as Factors of Production and Economic Fluctuations," *American Economic Review*, volume 79 (June 1989), pp. 338-354.

Salinger, Michael A. and Lawrence H. Summers. "Tax Reform and Corporate Investment: A Microeconomic Simulation Study," in Martin Feldstein ed., Behavioral Simulation Methods in Tax Policy Analysis, Chicago: University of Chicago Press, 1983.

Sargent, Thomas J. *Macroeconomic Theory*, New York: Academic Press, 1979.

Smith, Adam. *The Wealth of Nations*, New York: Random House, 1937.

Stiglitz, Joseph and Andrew Weiss. "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, vol. 71 (June 1981), pp. 393-410.

Summers, Lawrence H. "Taxation and Corporate Investment: A q-Theory Approach," *Brookings Papers on Economic Activity*, 1:1981, pp. 67-127.

Whited, Toni M. "Debt, Liquidity Constraints and Corporate Investment: Evidence from Panel Data," Princeton University, 1988.

Young, H. Kim and Venkat Srinivasan. *Advances in Working Capital Management*, Greenwich, Connecticut: JAI Press, 1988.

Zeldes, Stephen P. "Consumption and Liquidity Constraints: An Empirical Investigation," Journal of Political Economy, volume 97 (1989), pp. 305-346.

Table 1
Sample Summary Statistics

	Sample Mean	Sample Median
Estimated Replacement Value of Fixed Capital (millions of 1982 dollars)		
1970	85.4	19.3
1979	159.3	46.4
Working Capital Stock (millions of 1982 dollars)		
1970	47.5	14.1
1979	93.5	37.0
Real Sales Growth	15.7%	13.1%
Fixed Investment to Capital Ratio	0.247	0.176
Change in Working Capital to Capital Ratio	0.220	0.115
Cash Flow to Net Sources Ratio	0.715	0.686
Change in Debt to Net Sources Ratio	0.169	0.184
Value of New Share Issues to Net Sources Ratio	0.116	0.001
Dividend to Capital Ratio	0.006	0

Note: Net sources are defined as the sum of cash flow the change in debt, and the value of new equity. Mean observations for the net sources ratios are based on sample aggregates.

Table 2
Summary Statistics on Investment Smoothing

Variance of the Cash Flow to Capital Ratio (CF/K)	0.044
Variance of the Investment to Capital Ratio (I/K)	0.031
Variance of the Change in Working Capital to Capital Ratio (ΔW/K)	0.123
Correlation of CF/K and ΔW/K	0.534
Correlation of CF/K and the Change in Debt to Capital Ratio	0.185
Proportion of Years with Negative CF	0.058
Proportion of Years with Negative ΔW	0.214

Note: All the statistics in Table 2 are based on within-firm calculations (deviations from firm means).

Table 3

Investment Equation Estimates: Basic Specification
(Dependent Variable: I/K)

Independent Variable	Equation (3.1)		Equation (3.2)	
Q	0.0046	(4.5)	0.0054	(5.1)
CF/K	0.382	(11.2)	0.743	(6.4)
ΔW/K			-0.430	(3.4)

Note: Equation (3.1) was estimated with ordinary least squares. Equation (3.2) was estimated with instrumental variables as described in the text. Estimated t-statistics appear in parentheses after the coefficient estimates. Fixed firm and time effects are not reported.

Table 4

Investment Equation Estimates: Including Sales and Lagged Sales to Capital Ratios
(Dependent Variable: I/K)

Independent Variable	Equation (4.1)		Equation (4.2)	
Q	0.0036	(4.5)	0.0038	(4.2)
CF/K	0.217	(5.3)	0.385	(5.5)
ΔW/K			-0.222	(3.1)
S/K	0.052	(6.5)	0.057	(6.4)
S1/K	-0.034	(3.8)	-0.034	(3.5)

Note: Equation (4.1) was estimated with ordinary least squares. Equation (4.2) was estimated with instrumental variables as described in the text. Estimated t-statistics appear in parentheses after the coefficient estimates. Fixed firm and time effects are not reported.

Table 5

Investment Equation Estimates Including End-of-Period Q
(Dependent Variable: I/K)

Independent Variable	**Equation (5.1)**		**Equation (5.2)**	
Q (B.O.P)	0.005	(5.0)	0.004	(2.7)
Q (E.O.P.)	-0.002	(1.0)	0.003	(0.9)
CF/K	0.393	(11.0)	0.784	(5.9)
ΔW/K			-0.489	(3.7)

Note: Equation (5.1) was estimated with ordinary least squares. Equation (5.2) was estimated with instrumental variables as described in the text. Estimated t-statistics appear in parentheses after the coefficient estimates. Fixed firm and time effects are not reported.

Table 6

Investment Equation Estimates: High Dividend Firm Sample
(Dependent Variable: I/K)

Independent Variable	**Equation (6.1)**		**Equation (6.2)**		**Equation (6.3)**		**Equation (6.4)**	
Q	0.002	(6.7)	0.002	(7.7)	0.002	(6.0)	0.002	(6.4)
CF/K	0.185	(13.8)	0.299	(14.1)	0.038	(2.2)	0.059	(3.0
ΔW/K			-0.180	(7.0)			-0.051	(2.3)
S/K					0.030	(10.1)	0.033	(10.2)
S1/K					0.001	(0.1)	-0.002	(0.7)

Note: Equations (6.1) and (6.3) were estimated with ordinary least squares. Equations (6.2) and (6.4) were estimated with instrumental variables as described in the text. Estimated t-statistics appear in parentheses after the coefficient estimates. Fixed firm and time effects are not reported.

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