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Inventory Investment, Internal-Finance Fluctuations, and the Business Cycle

It is a well-known fact that inventory disinvestment can account for much of the movement in output during recessions. Almost one-half of the shortfall in output, averaged over the five interwar business cycles, can be accounted for by inventory disinvestment, and the proportion has been even larger for postwar recessions.[1] A lesser-known fact is that corporate profits, and therefore internal-finance flows, are also extremely procyclical and tend to lead the cycle. Wesley Mitchell finds that the percentage change in corporate income over the business cycle is several times greater than that in any other macroeconomic series in his study.[2] Robert Lucas lists the high conformity and large variation of corporate income as one of the seven main qualitative features of the business cycle.[3] The volatility of internal finance, which is also com-

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1. See Abramovitz (1950, p. 5) and Blinder and Maccini (1991a).
2. Mitchell (1951, p. 286). These series include the rate of bankruptcy, employment, and pig iron production, among others.
3. Lucas (1977, p. 9).

monly referred to as cash flow, continues to be a salient feature of postwar cycles.

This paper links these two stylized facts by examining whether fluctuations of internal finance are an important cause of changes in inventory investment. Our exploration is motivated by a rapidly growing body of theoretical research arguing that changes in either internal finance or net worth will affect firm behavior if the markets for external finance are imperfect. Although most previous empirical work in this area has focused on fixed investment, the dramatic cyclical fluctuations in both inventory investment and internal finance suggest that efforts to examine their possible link are overdue.

When capital markets are imperfect, fluctuations of internal finance should affect all components of investment. We argue, however, that inventories should be especially sensitive to such imperfections. In response to a negative shock to internal finance, financially constrained firms will reduce their accumulation of all assets, with the effect on each asset determined by its relative liquidation and adjustment costs. Because inventory investment has low adjustment costs, its share of a decline in total investment caused by the contraction of internal finance will be disproportionately large relative to fixed investment or other uses of funds (research and development, for example).

While the modern literature on inventories typically excludes financial effects, the connection between internal finance and inventory investment may help resolve an empirical puzzle about inventory behavior. Numerous studies have found that production varies more than sales and that inventory investment is positively correlated with contemporaneous sales shocks.[4] Both results are inconsistent with the production-smoothing model that predicts inventories will buffer production from sales shocks. These findings may arise from an omitted-variable bias. The presence of financing constraints induces a positive correlation between inventory investment and internal-finance flows. When internal-finance variables are excluded from inventory investment regressions, the coefficient on contemporaneous sales may reflect the impact of financing constraints, overwhelming any negative correlation caused by buffer-stock effects alone.

We test for a linkage between inventory investment and internal fi-

4. See, for example, Blinder (1986b) and the references provided there.

nance by estimating a standard inventory investment model augmented by measures of internal finance. The data are taken from Compustat's quarterly "full coverage" files for manufacturing firms. The sample period from 1981 to 1992 contains pronounced swings in inventory investment as well as large fluctuations in internal finance, with troughs in 1982, 1986, and 1991. To our knowledge, our study is the first work on the microfoundations of cyclical firm behavior to employ a data set with three key features: (i) firm-level panel data, (ii) high-frequency data (quarterly), and (iii) data covering a major fraction of the aggregate economy. The structure of these data provides several important methodological advantages.

First, with firm-level panel data, we include both fixed firm effects and highly disaggregated industry time dummies. The fixed firm effects control for the many possible time-invariant determinants of inventory investment that differ across firms. The disaggregated time dummies control for a wide range of alternative hypotheses about inventory movements that would be observationally equivalent in tests based on aggregate time-series data.[5] For example, an alternative explanation to our hypothesis is that cost or technological shocks at the aggregate or industry level drive both internal finance and inventory investment. By including industry time dummies to control for these shocks, however, the influence of cost shocks can be disentangled from other variables. Indeed, because cost shocks at industry or higher levels of aggregation are often invoked to explain cyclical phenomena, we believe the empirical approach pursued here is applicable to a wide class of macroeconomic issues.

A second feature of our method, critical to our study and new in the literature, is the use of *quarterly* firm data. This innovation is especially important for a high-frequency phenomenon such as inventory investment; one could miss important cyclical variations in annual data. Perhaps more important, quarterly data increase the number of time-series observations. We can therefore run regressions, in the time dimension of the panel, for very short calendar periods (such as two or three years). The cross-sectional breadth of the data in combination with its high frequency allows standard panel data techniques to be used to examine *in-*

5. Most of our regressions include time dummies for each four-digit SIC (standard industry classification) industry. In contrast, previous panel studies in the financing-constraint literature have included only aggregate time dummies.

dividual cycles. We can test directly Lucas's assertion that "business cycles are all alike" and Victor Zarnowitz's suggestion that "although individual cycles share important family characteristics, they are by no means all alike."[6]

Finally, our data cover a large portion of the macroeconomy. Our sample accounts for over half of aggregate manufacturing inventories. This extent of coverage enhances our ability to draw conclusions relevant to macroeconomics as well as microeconomics.

Turning to our findings, the results show an economically important link between internal finance and inventory investment. As in previous empirical studies of financing constraints on fixed investment, we test across firms for the heterogeneity of internal-finance effects on inventory investment. Splitting our sample by firm size, we find that small firms have larger internal-finance effects than large firms. However, internal finance is economically important even for large firms, a finding that helps establish the macroeconomic significance of our findings. We also find heterogeneity in internal-finance effects across time periods. In particular, fluctuations in internal finance are more important for inventories during the 1981–82 recession than during the 1990–91 recession. This finding is consistent with the smaller role played by inventory disinvestment in the most recent recession relative to the previous recession, even though declines in internal finance were pronounced in both periods. The results are robust to the inclusion of additional variables to control for expectations, alternative estimation procedures, and different specifications (including measures of access to external finance). An alternative sample split based on bond ratings also provides consistent results.

The next section reviews related literature, discusses why internal finance is so volatile for the modern corporation, and describes why inventory investment is likely to be particularly sensitive to short-run fluctuations in internal finance. Subsequent sections provide the empirical models, summary statistics, and regression results.

Before concluding, we also discuss the macroeconomic implications of our findings and a new perspective on the cyclical volatility of inventory investment. Because inventory investment accounts for such a large fraction of aggregate volatility, many economists have argued that

6. Lucas (1977, p. 10) and Zarnowitz (1992, p. 3).

reducing inventory fluctuations could dampen the business cycle. However, if financing constraints play a role in propagating the cycle, this view is incomplete. Internal-finance shocks that are not absorbed by inventory investment will affect other components of investment. For example, if firms enter a recession with unusually low inventory stocks, then the reduction in fixed investment is likely to be greater. Thus, the sum of investment in all assets may continue to be volatile even if inventory fluctuations are dampened. This perspective helps to explain differences in the composition of total-investment shortfalls in previous contractions; in particular, we compare the 1981–82 and 1990–91 recessions.

Inventory Investment and Internal Finance

This section of the paper motivates the linkage between inventory investment and internal finance. The hypothesis consists of three main ideas: (i) financing constraints exist and may be important for a large portion of the economy; (ii) for many firms, and for much of the economy, fluctuations in internal finance are extremely large over the business cycle; and (iii) financially constrained firms will choose to absorb a disproportionately large amount of internal-finance shocks with inventory (dis)investment. Each of these ideas is discussed below, along with the findings of some related studies.

Related Literature

The connection between inventory fluctuations and the business cycle has been a major concern of macroeconomists for years, and for good reason. While inventory investment accounted for less than 1 percent of GNP, on average, between 1959 and 1991, Alan Blinder and Louis Maccini find, in a purely arithmetic sense, that reductions in inventory investment, on average, account for about 87 percent of the drop in real output in postwar recessions. Their argument that "the inventory accelerator created cycles *that otherwise might not exist*" (emphasis added) reflects a central role for inventories in the theory of the business cycle, dating back at least to the work of Lloyd Metzler.[7]

7. Blinder and Maccini (1991a, p. 73) and Metzler (1941).

The dramatic role played by inventories in macroeconomic downturns, however, poses a puzzle when viewed from a microeconomic perspective. Standard theory predicts that optimizing firms with convex costs will smooth production relative to sales, and, when demand is stochastic, firms will use inventories as a buffer against temporary demand shocks. Thus, the model predicts that inventory investment should dampen cyclical fluctuations in output. Most empirical evidence, however, rejects the production smoothing–buffer stock model, finding that production varies more than sales and that the covariance between inventory investment and sales is positive.[8] These findings have generated research addressing the "excess volatility" of inventories from a variety of perspectives, including work emphasizing cost shocks, increasing returns, and firms' desire to avoid losing sales because of inventory stockouts.[9]

An alternative explanation for the volatility of inventories is that capital market imperfections can limit firms' access to external finance, leading to fluctuations in all types of investment, including inventories. This link between fluctuations of inventory investment, internal finance, and the availability of external finance has been considered in an earlier literature. Paul Kuznets, in a study of data from the Department of Commerce *Quarterly Financial Reports* (*QFR*), finds that "[a] firm's ability to finance inventory investment without resorting to borrowing is determined, finally, by earnings and depreciation flows or what might be termed 'internal finance'."[10]

Several recent papers have argued that monetary policy can affect firms' access to finance, which in turn affects inventory investment. Benjamin Friedman and Kenneth Kuttner link monetary policy, financial conditions (measured by both prices and quantities from financial markets), and real economic activity, including inventory behavior. Anil Kashyap, Jeremy Stein, and James Wilcox estimate vector autoregressions with aggregate data and find that financial factors (the prime–

8. See Blinder and Maccini (1991a) for references. Exceptions include papers by Ghali (1987), Fair (1989), Krane and Braun (1991), and Kashyap and Wilcox (1993).

9. For example, Eichenbaum (1989) argues that cost shocks provide firms with incentives to "bunch" production in periods of low cost. Ramey (1991) finds evidence of declining marginal costs that would also motivate production bunching. Blinder and Maccini (1991a) argue that production may vary more than sales if firms follow (S,s) inventory rules.

10. Kuznets (1964, p. 336).

commercial paper spread and the mix of bank loans and commercial paper) have a significant correlation with inventory investment.[11] Mark Gertler and Simon Gilchrist, using time-series data from the *QFR* aggregated separately for small and large manufacturing firms, compare the output and inventory response to monetary shocks across the two size classes. They find that small firms "play a surprisingly prominent role in the slowdown of aggregate inventory demand" after monetary contractions, and they argue that this result is due to capital market imperfections faced by small firms.[12] Finally, Kashyap, Owen Lamont, and Stein examine three separate cross-sections of annual manufacturing-firm data. They find that a stock measure of liquidity (cash plus marketable securities) is significant in explaining the inventory growth of firms without bond ratings in the 1982 cross-section but is not significant for firms with bond ratings. The liquidity stock variable is not significant for any category of firms in cross-sections after 1982.[13]

One difference between the paper by Gertler and Gilchrist and the one by Kashyap, Lamont, and Stein is that the former uses aggregate time-series data while the latter examines cross-sections of firms. Both of these empirical approaches differ from ours since we exploit panel data on firms, which provide the advantages discussed in the introduction. In addition, our study focuses on fluctuations in the flow of internal finance over the cycle, while the other two papers are primarily concerned with the effects of monetary policy and firms' access to external finance, particularly bank finance. We also find more pervasive evidence of a link between financing constraints and inventory investment: our results indicate economically important effects of internal finance not just for small firms but also for large firms.

Presence of Financing Constraints

Research on capital markets provides several reasons to believe that many, perhaps most, firms face a financing hierarchy, in which external finance is substantially more expensive (if available at all) than internal

11. See Friedman and Kuttner (1993) and Kashyap, Stein, and Wilcox (1993).

12. Gertler and Gilchrist (1994, p. 311). This article also presents results showing that the ratio of cash flow to interest expense (which the authors interpret as a proxy for balance sheet conditions) affects inventory investment for small firms but not for large firms.

13. Kashyap, Lamont, and Stein (1994).

finance. Flotation costs, bankruptcy costs, and distortionary taxes create such a hierarchy. In addition, theoretical work has demonstrated that asymmetric information between firms and potential suppliers of external finance can cause adverse selection problems in equity markets and adverse selection and moral hazard problems in debt markets.[14] In theory, these problems create a wedge, which may be very large, between the cost of internal and external finance. In some cases, firms may be completely rationed in markets for external finance. Many recent empirical studies have found evidence that supports the presence of financing constraints for a substantial fraction of firms in the United States and other countries.[15] These studies include both reduced-form regressions of fixed investment on internal finance as well as Euler-equation investigations of firms' investment behavior. Several theoretical papers extend the significance of financing constraints to macroeconomics, arguing that such constraints can play an important role in propagating business cycles.[16]

Financing constraints are not expected to affect all firms equally or to be invariant over time. Indeed, testing for the possible heterogeneity of financing constraints across firms has become a dominant theme in the literature. There are several reasons to believe that small firms may face greater costs in accessing external finance than large firms. Public information on small firms is less available, leading to greater asymmetric information and more severe adverse selection and moral hazard problems. Small firms rely more heavily on bank debt than large firms, and they rarely issue corporate bonds or commercial paper. For most small firms, bank debt may be the only option available to replace lost internal finance.

Even many large firms are likely to find it costly, perhaps prohibitively so, to replace lost internal finance during a recession with publicly traded debt. Charles Calomiris, Charles Himmelberg, and Paul Wachtel provide evidence showing that very few manufacturing firms have access to both commercial paper, the only publicly traded form of short-

14. See, for example, Stiglitz and Weiss (1981), Myers and Majluf (1984), and the survey by Gertler (1988).

15. For example, see Fazzari, Hubbard, and Petersen (1988), Gilchrist (1989), Devereux and Schiantarelli (1990), Hoshi, Kashyap, and Scharfstein (1991), Whited (1992), Oliner and Rudebusch (1992), and Dorothy Petersen (1993).

16. See, for example, Greenwald and Stiglitz (1988) and Bernanke and Gertler (1989).

term debt, and corporate bonds.[17] They find that only approximately 8 percent of Compustat firms have commercial-paper programs. These firms are very large (with mean quarterly sales exceeding $1.5 billion), and they have very high bond ratings. Another 12 percent of Compustat firms issues bonds but does not have commercial-paper programs, and these firms typically have lower bond ratings.

In general, external finance appears to be strongly procyclical. Calomiris, Himmelberg, and Wachtel find that commercial-paper issuance is procyclical at the firm level. George Perry and Charles Schultze present evidence showing that short-term credit flows are negative around the troughs of three of the last four recessions.[18] These facts suggest that, in the aggregate, short-term debt does not offset reductions in internal finance during recessions.

If firms must pay a large premium for new debt or equity, or if they are rationed in external credit markets, internal-finance flows from profits and depreciation allowances provide an important, perhaps essential, source of finance for all kinds of investment. Internal finance is the largest source of funds for U.S. corporations.[19] In addition, a majority of public firms do not pay dividends (56 percent of Compustat firms in 1990), suggesting the prevalence of binding financial constraints. Investment activities for such firms are likely to vary with their flow of internal funds. Furthermore, because cuts in dividends appear to transmit negative signals about a firm's prospects to financial markets, even dividend-paying firms may choose to curtail investment activities rather than reduce dividends when internal finance declines.[20] This outcome is especially likely over the short horizons relevant for cyclical fluctuations.

Volatility of Internal Finance

Of central importance to the argument in this paper is the fact that business income, and therefore internal finance, is volatile over the busi-

17. Calomiris, Himmelberg, and Wachtel (1994, p. 36).

18. Calomiris, Himmelberg, and Wachtel (1994) and Perry and Schultze (1993, table 10). Also see Friedman and Kuttner (1993, figure 12).

19. Fazzari, Hubbard, and Petersen (1988, table 1) present *QFR* statistics showing that retained earnings account for 71.1 percent of sources of funds for all manufacturing firms. The percentages are higher for small firms.

20. See, for example, Lintner (1956) and Dielman and Oppenheimer (1984).

ness cycle. Mitchell has documented the extreme procyclical movements of internal finance, finding that the percentage change in business income, the largest component of internal finance, has an amplitude several times greater than any other series in his study.[21] Postwar data from the *QFR* show that business income continues to be extremely volatile over the cycle. Real business income fell 47 percent from 1981:3 to 1982:4 and then more than doubled in the early stages of the recovery. Income fell 39 percent from 1984:2 to 1986:1 as growth slowed and the economy narrowly avoided a recession. During the most recent recession, business income fell 53 percent from its peak in 1989:1 to its trough in 1991:1.[22]

Business income is highly procyclical for at least two reasons. First, sales and revenue fall, often very sharply, just before and during recessions. Perry and Schultze state that "weakness in final sales over the four quarters leading up to recession comes close to being a feature of the economy that predicts recessions."[23] Second, a large fraction of firms' labor and capital costs are fixed or quasi-fixed in the short run. With high fixed costs, relatively small movements in revenue can cause large proportionate changes in internal finance, particularly since cash flow is such a small fraction of sales for the typical firm.[24]

In the modern corporation, much of labor cost is quasi-fixed in the short run. One reason is that hiring and training costs can be very large, especially for nonproduction workers.[25] According to the Census of Manufacturing, nonproduction workers in 1981–82 accounted for over 34 percent of total workers and more than 45 percent of payroll costs. The "hoarding" of nonproduction workers is evident in manufacturing during recessions. For example, during the recession in 1982, census figures indicate that the employment of nonproduction workers fell by only 0.4 percent. As a result, total payroll (in 1982 dollars) fell by only 2.5 percent, less than half the percentage decline in the real value of ship-

21. Mitchell (1951).

22. *Quarterly Financial Reports* are from the U.S. Department of Commerce.

23. Perry and Schultze (1993, p. 148).

24. For Fortune 500 companies in 1992, the median profit-to-sales ratio was 2.4 percent (*Fortune*, April 19, 1993, p. 214).

25. For example, see the review of the literature on hiring and training costs in Parsons (1986, pp. 793–94).

ments.[26] The apparent fixity of nonproduction workers magnifies the effect on internal finance brought on by any change in revenue.

Why Is Inventory Investment Particularly Sensitive to Internal-Finance Shocks?

Extreme declines in internal finance force financially constrained firms to curtail their accumulation of all assets. However, a firm in this situation should not cut investment proportionately across all assets. In previous work, we point out that even financially constrained firms will seek to equate the marginal returns on different investments, *net of adjustment costs*, at each point in time. Therefore, relatively liquid assets with low adjustment costs, such as inventories, should bear the brunt of temporary negative shocks to internal finance. Symmetrically, improvements in internal finance during economic recoveries should induce the fastest accumulation of those same assets. Several studies indicate that fixed investment and research and development (R&D), the other main components of investment expenditure, have much greater adjustment costs than inventories.[27]

Unlike largely irreversible investments in R&D and fixed capital, firms can, and often do, dramatically cut their stocks of inventory. Reducing the proportion of internal finance devoted to inventory accumulation releases liquidity, thus relaxing the short-run financing constraints on the other investment activities of firms. Most inventory studies focus on finished goods, and although firms can build liquidity by operating with a smaller ratio of finished goods to sales, raw-materials and work-in-process inventories are much more volatile. Blinder and Maccini report that raw materials make up approximately 40 percent of

26. The U.S. Department of Commerce's Bureau of the Census conducts this broad survey of U.S. companies every five years.

27. Fazzari and Petersen (1993) and Carpenter (1992). Zarnowitz (1992, p. 41) writes that inventories can be adjusted more quickly than fixed capital. Himmelberg and Petersen (1994) argue that R&D has high adjustment costs and report evidence that R&D is unresponsive to temporary cash flow shocks. Chirinko (1993) estimates Euler equations for firms with multiple capital inputs and finds that inventories have low and statistically insignificant adjustment costs, while adjustment costs are significant and positive for R&D capital, fixed capital, and labor. For further discussion, see the review of research on adjustment costs in Fazzari and Petersen (1993).

total manufacturing inventories and are much more volatile than either work-in-process or finished goods inventories.[28] A firm can readily disinvest a portion of its raw-materials stock by simply consuming it in production and delaying reordering. The firm temporarily operates with lower-than-normal stocks of raw materials, which releases liquidity in the short run. Work-in-process inventories can be liquidated in a similar manner.

There is, however, a cost to reducing inventory stocks. Inventories can be viewed like any other input to production.[29] As the levels of inventory stocks fall, their marginal product rises and it becomes more costly for firms to sacrifice inventories at the margin. The extent to which inventory investment responds to internal-finance fluctuations depends on the initial stock of inventories. Differences in the initial stocks may therefore help to explain variations in the behavior of inventory investment across business cycles. We develop this point later in the paper by comparing inventory investment shortfalls in the 1981–82 and 1990–91 recessions.

In sum, inventories constitute a large and relatively flexible part of firms' assets, providing potential liquidity to offset shocks to internal finance. Therefore, if financing constraints are important, we expect aggregate inventory investment to absorb a disproportionate share of internal-finance movements.

Empirical Specification

To test the link between internal finance and inventory accumulation, we modify a widely used inventory investment equation. For firm j at time t (measured in quarters), we assume

$$\begin{aligned}(1)\qquad \Delta N_{jt} &= \lambda\,(N_{jt}^{*} - N_{jt}) - \alpha\,(S_{jt} - E_{t-1}\,S_{jt}) \\ &\quad + \beta_0\,CF_{jt} + \beta_1\,CF_{jt-1} + \beta_2\,CF_{jt-2} + e_{jt},\end{aligned}$$

where ΔN_{jt} is inventory investment in period t, N_{jt} and N_{jt}^{*} denote the actual and target stocks of inventories at the beginning of period t, S_{jt} and $E_{t-1}S_{jt}$ represent the actual and forecasted levels of sales, and CF_{jt} represents cash flow, or the flow of internal finance. Blinder and Maccini

28. Blinder and Maccini (1991b, p. 295).
29. This point is emphasized by Ramey (1989).

describe the first two terms in equation 1 as "anticipated" and "unanticipated" inventory investment.[30] The stochastic term e_{jt} may include aggregate and seasonal effects along with random errors, as discussed below.

The stock adjustment term in equation 1 $(N^*_{jt} - N_{jt})$ relates the change of inventories to the gap between the target stock of inventories and the actual beginning-of-period stock. The speed of adjustment is given by the parameter λ. The target stock is often related to expected sales. For finished goods inventories, this link comes from a stockout-avoidance motive.[31] As expected sales rise, the probability of a costly stockout increases, inducing firms to hold more finished goods in inventory. To the extent that expected sales vary with recent actual sales, an inventory accelerator is generated that may explain part of inventory investment volatility. For work-in-process and raw-materials inventories, similar accelerator effects arise through the target stock because these inventory components can be modeled as factors of production.[32] The demand for these inputs varies with actual and expected sales as well.

We use a common model for target inventories:

$$N^*_{jt} = \gamma_j + \gamma_1 E_{t-1} S_{jt} + w_{jt}, \tag{2}$$

where w_{jt} is a random error term. In addition to expected sales, the target inventory level depends on a "fixed effect" (γ_j) that varies across firms. Blinder develops a model that motivates this fixed-effect term. He writes that desired inventories depend on firm-specific variables that "would not be expected to change very often or very quickly."[33] Since some between-firm determinants of N^* are likely to be correlated with sales and cash flow (for example, long-run firm demand and technological conditions, such as inventory storage costs), failure to control for unobservable fixed firm effects will likely lead to inconsistent parameter estimates in equation 1. Indeed, a Hausman test based on our regressions strongly rejects the independence of firm effects from the other regressors.

30. Blinder and Maccini (1991b, p. 303). Blanchard (1983) finds that an equation incorporating the first two terms of equation 1 performs about as well in explaining automobile inventory investment as an explicit structural model derived from a quadratic technology.

31. See West (1986) and Kahn (1987).

32. See Ramey (1989).

33. Blinder (1982, p. 342).

The second term in equation 1 arises from the role of inventories as a buffer stock when firms smooth production. If actual and forecasted sales differ, inventory investment could reflect part of the difference, giving the sales forecast error a negative effect on inventory investment. Equation 3 is an autoregressive forecast for sales similar to that used by Blinder:[34]

$$(3) \qquad E_{t-1} S_{jt} = \delta_j + \delta_1 S_{jt-1} + \delta_2 S_{jt-2} + v_{jt},$$

where δ_j is a fixed firm effect and v_{jt} is a random expectation error. This specification may appear restrictive since firms might anticipate some part of actual sales in period t based on information other than that contained in lagged sales. Because of the buffer-stock term in equation 1, however, our regression equation includes contemporaneous sales. Therefore, the model controls for any correlation between expected sales and actual contemporaneous sales not explained by lagged sales. This potential correlation affects our ability to identify the buffer-stock coefficient α but does not affect the estimation of the cash flow coefficients.

The cash flow terms in equation 1 are the main focus of our study. The approach here, directly linking a firm's asset accumulation to its cash flow, is analogous to that taken by many authors in their tests of the impact of financing constraints on fixed capital investment.[35] The timing of the cash flow effect is important. Previous fixed investment studies use annual data and emphasize contemporaneous cash flow. Because we use quarterly firm data, it is quite possible that financing constraints will be reflected in lags of cash flow.

Estimating Equation

Substituting equations 2 and 3 into inventory investment equation 1 yields the regression equation:

$$(4) \quad \Delta N_{jt} = -\lambda N_{jt} - \alpha S_{jt} + \delta_1 (\alpha + \lambda\gamma_1) S_{jt-1} + \delta_2 (\alpha + \lambda\gamma_1) S_{jt-2}$$
$$+ \beta_0 CF_{jt} + \beta_1 CF_{jt-1} + \beta_2 CF_{jt-2} + \theta_j + \theta_{it} + u_{jt},$$

where θ_j is the linear combination of fixed firm effects and u_{jt} is the linear

34. Blinder (1986a).

35. See, for example, Fazzari, Hubbard, and Petersen (1988) and Hoshi, Kashyap, and Scharfstein (1991).

combination of stochastic error terms from equations 1 through 3. The fixed firm effects control for any time-invariant determinants of inventory investment across firms. The variable θ_{it} represents time effects for industry *i* at time *t*. (We discuss the importance of these effects in the next subsection.) In the estimated regressions, all the variables are scaled by the firm's beginning-of-quarter total assets (TA_{jt}) to control for heteroscedasticity.

The first four variables in equation 4 can be interpreted in the context of a production-smoothing model. In the results section, we compare the coefficients on these variables with previous findings in the inventory literature. For most of the purposes of our paper, however, the first four variables can be thought of as controls, allowing us to test the importance of internal finance after controlling for the accelerator, or sales, and stock-adjustment effects.

A concern sometimes raised in the empirical literature on financing constraints is that positive cash flow coefficients may arise if cash flow variations contain new information about investment opportunities not captured by variables that control for investment demand. There are several responses to this concern. First, because of the reversibility of inventories, inventory investment should respond to short-term expectations, which are likely to be highly correlated with current sales, a variable included in all our regressions. Second, as emphasized in much of the literature, if cash flow only proxies for expectations, one would expect its effects to be similar for both small and large firms. Conversely, a finding of *different* cash flow effects across firm sizes strongly suggests that cash flow is important as a source of finance. Finally, to test the robustness of the specification given in equation 4, we include changes in stock prices and leads of sales, two variables that directly measure expectations.

Recognizing the importance of sales as a control for inventory demand leads to another concern about the specification of equation 4: sales and cash flow may be highly collinear. Our large microeconomic data set, however, is well suited to identifying these separate effects since it contains considerable firm-specific variation in cash flow that is independent from changes in sales.[36] This fact is not surprising given the

36. A regression of the cash flow–asset ratio on contemporaneous and two lagged values of the sales-to-asset ratio gives a highly significant coefficient on sales, but has an R^2 of only 18 percent.

wide variety of factors that prevent cash flow from moving proportionately with sales. These factors include short-run fixed or quasi-fixed costs; nonlinearities in firms' technologies; tax effects; interest expenses; and selling, general, and administrative expenses. Indeed, as documented above, cash flow is much more volatile than sales. In our micro data, the coefficient of variation for cash flow is nearly five times larger, on average, than that for sales, as is documented below.

Time and Seasonal Effects

The use of firm-level panel data makes it possible to include fixed time effects; an innovation here is to define these effects at a highly disaggregated industry level. This approach provides a general way to control for alternative explanations of inventory volatility. For example, including time dummies for each industry is an effective method of controlling for cost shocks. Several recent papers emphasize that favorable temporary cost shocks might cause optimizing firms to "bunch" production into low-cost periods, causing high inventory investment.[37] Also, other things equal, when costs are low, cash flow will be high. Therefore, in the absence of a control for cost shocks, such shocks might induce a spurious correlation between cash flow and inventory investment.

We include time dummies disaggregated to the four-digit SIC industry level (denoted by θ_{it} for industry i at time t). These dummies control for any industry-level technological shocks as well as industrywide movements in the costs of labor, raw materials, and capital. (Studies based on aggregate or industry data, which dominate the inventory investment literature, do not have the cross-sectional heterogeneity to control for these effects.) In regressions that include time dummies, the cash flow results cannot be attributed to any time-varying effects disaggregated to the four-digit SIC level.[38] The disadvantage of including time

37. Evidence on the importance of cost shocks is mixed. Eichenbaum (1989) finds that his "production-cost smoothing" model cannot be rejected while the "production-level smoothing" model is rejected. Maccini and Rossana (1984) as well as Blinder (1986a) find some effect of raw-materials costs on finished goods inventory investment, but virtually no effects of interest rates or wages. Nerlove, Ross, and Wilson (1993) find that cost shocks are "rarely significant" in survey data. Miron and Zeldes (1988) also find little evidence for the importance of cost shocks.

38. The only remaining shocks that cannot be controlled for are those that are idiosyncratic to individual firms.

dummies, however, is that they remove the common cyclical variance of inventory investment and cash flow for each industry. Therefore, we also estimate equations with four-digit quarter dummies rather than with the full set of time dummies. In addition, we add explicit cost variables to some of the regressions; they include interest rates, wage costs, and energy costs.[39]

Finally, inventory investment has a strong seasonal component. Our four-digit time dummies control for seasonality at the industry level. Nerlove, Ross, and Wilson argue that time dummies are the best way to control for seasonality in inventory studies.[40] In fact, in regressions with quarter dummies (but not year-quarter dummies), we have sufficient degrees of freedom to include dummies for every firm. This procedure gives very similar results to that using four-digit quarter dummies.

Data Description and Summary Statistics

We construct our sample from the Compustat quarterly data tapes for the period 1981–92. The quarterly tapes contain data on the income statements and balance sheets of several thousand publicly traded companies. To date, Compustat's quarterly data have been virtually untapped by researchers examining the financial and investment behavior of firms.[41]

We choose a set of easily reproducible rules for the construction of our three panels. All firms in our sample are domestically incorporated. We require that each panel be balanced and exclude the extreme lower tail of the size distribution because many of these firms are startup operations, often with zero inventories and negative cash flows.[42] We also exclude all mergers identified by Compustat because they could gener-

39. A similar approach is used by Maccini and Rossana (1984) and Blinder (1986a).

40. See Nerlove, Ross, and Wilson (1993). Beaulieu, MacKie-Mason, and Miron (1992) report significant differences in the seasonal cycles of two-digit SIC manufacturing industries.

41. Our data include quarterly information for every active firm covered by the annual Compustat data. Data are available quarterly for total inventories but not for the separate components: finished goods, raw materials, and work-in-process.

42. We exclude firms with less than $10 million in assets. Firms below this cutoff account for only a small fraction of inventory investment. Changing the cutoff value to $5 million had little effect on the results. Even though a firm is excluded from one period, it may enter others if it reaches $10 million in assets.

ate discontinuities in the stocks of inventory. To protect against results driven by a small number of extreme observations, we exclude observations in the 1 percent tails for each regression variable.[43] Our resulting sample covers a substantial portion of aggregate manufacturing inventories (54.5 percent over the full sample period). Since manufacturing accounts for over half of aggregate inventories, our sample has clear relevance for explaining macroeconomic inventory behavior.

The sample period contains three distinct inventory cycles, including the 1981–82 and the 1990–91 recessions. We split the data into three panels: 1981:1–1983:4, 1984:1–1988:3, and 1988:4–1992:4, where the splits are determined by the peaks in aggregate inventory investment. There are several advantages to analyzing several short panels as opposed to one long panel. First, we lose comparatively few firms from balancing each panel, an important consideration since Compustat expanded its coverage during the 1980s. Second, short panels reduce the likelihood of introducing trends that might dominate cyclical movements in the data. Third, we can examine the heterogeneity of our results across different time periods, which is valuable because of differences in prevailing financial market conditions. Finally, a comparison of parameter estimates across panels provides a test of the robustness of our findings.

If firms do not have equal access to external financial markets, the sensitivity of investment (of all types) to internal-finance fluctuations will differ across firms. As discussed in our review of the financing-constraint literature, researchers have divided samples according to retention ratios, bond ratings, and firm size. For most of our regressions, we split the data according to firm size as a proxy for access to external finance. As an alternative test for heterogeneity, we also compare results for firms with bond ratings with those for firms without bond ratings.[44]

We place firms with less than $300 million in average total assets (in 1987 dollars) into the small firm-size class. Similar cutoffs have been used elsewhere to distinguish small from large firms.[45] This cutoff also gives an approximately equal number of firms in each class during the

43. We ran all the main regressions (presented in tables 4 and 5 below) with several different outlier cutoffs ranging from 0.5 to 2.0 percent. The results were not significantly affected by using these different cutoffs.

44. See Whited (1992) and Kashyap, Lamont, and Stein (1994).

45. See Scherer and Ross (1990, table 3.1) and Gertler and Gilchrist (1994).

Table 1. Medians of Selected Firm Characteristics, 1981–92
Units as indicated

Characteristic	*1981:1–1984:1*		*1984:2–1988:3*		*1988:4–1992:4*	
	Small firms	*Large firms*	*Small firms*	*Large firms*	*Small firms*	*Large firms*
Number of firms	241	247	441	230	594	280
Employment (thousands)	1.5	17.0	0.9	12.8	0.7	10.0
Total assets (millions of 1987 dollars)	97.6	1,485.6	63.8	1,386.8	62.5	1,251.4
Inventories (millions of 1987 dollars)	23.3	271.0	14.9	215.5	14.2	198.8
Sales (millions of 1987 dollars)	35.8	485.1	20.1	386.9	19.3	337.8
Sales growth (annualized percent)	−0.8	−2.8	5.7	4.9	3.2	1.6
Ratios						
Cash flow to net sources of finance[a]	0.863	0.927	0.875	0.881	0.926	0.857
Stock issues to net sources of finance[a]	0.002	0.010	0.004	0.010	0.002	0.005
Debt issues to net sources of finance[a]	0.022	0.015	0.047	0.071	0.000	0.067
Retention[b]	0.793	0.618	0.982	0.677	1.000	0.705

Source: Authors' calculations from Compustat data.
a. Total net sources of finance are the sum of cash flow, funds raised from the net sale of common and preferred stock, and the change in total debt.
b. Ratio of net income less total dividends to net income.

first period. For comparability, we use the same cutoff in the other two periods. We experimented with several other cutoffs around $300 million with little effect on the results. Small firms account for a significant fraction of manufacturing. Gertler and Gilchrist report *QFR* statistics showing that over 32 percent of manufacturing sales is accounted for by firms with less than $300 million in assets.[46]

Table 1 reports size statistics and sources of finance for all three panels. The pronounced differences between small and large firms are readily apparent. The median large firm is more than ten times larger than the median small firm in our panels. Median total assets for small firms in the first period are $98 million versus $1.5 billion for large firms. Small firms employ a median of 1,500 employees and have median sales of $36 million. By contrast, median employment for large firms is approximately 17,000 and large firms have median sales of $485 million.

46. Gertler and Gilchrist (1994).

The differences between firms in the two size classes become more pronounced in the second and third periods with the expansion of Compustat's coverage of small firms. The summary statistics also indicate that inventories constitute a considerable fraction (16–24 percent) of total assets in both size categories and in all three time periods.

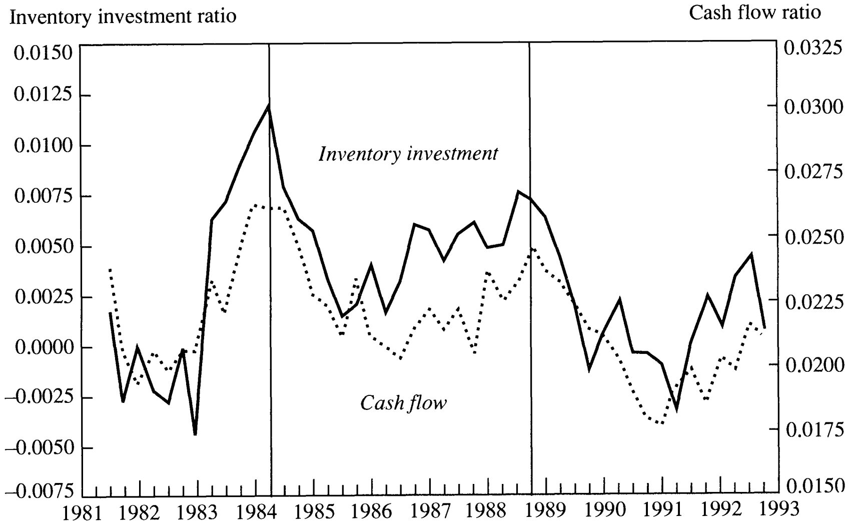
The second half of table 1 reports statistics on sources of finance. Small firms pay very few, if any, dividends. The median retention ratio, which we define as the ratio of income less dividends to income, is 0.79, 0.98, and 1.00 for small firms in each period, respectively, compared with 0.62, 0.68, and 0.71 for large firms. The higher retention ratios for small firms are consistent with the view that small firms are more likely to face binding financing constraints. Dividing our sample by size roughly approximates a sample split based on positive dividend payments. We define total net sources of finance as the sum of cash flow, funds raised from the net sale of common and preferred stock, and the change in total debt. The largest source of finance for both groups of firms is cash flow. The median cash flow–to–net sources ratio is 0.85 or greater for both size categories and for all periods. The least important source of finance in our sample is new equity. The median value of new shares to total sources for all firms amounts to less than 1 percent of their funds. (Note that the median ratios will not sum to unity.) The proportion of funds raised through new debt is also relatively small for both groups of firms. Overall, the numbers in the table suggest that the median firm makes modest use of external finance compared with internal finance.

Comovements of Inventories and Cash Flow

Figures 1 and 2 show the seasonally adjusted plots of the quarterly means for inventory investment and cash flow for both small and large firms. Both variables are scaled by beginning-of-quarter total assets. The left-hand scale refers to inventory investment; the right-hand scale refers to cash flow. Vertical lines represent the period boundaries. (As can be seen from figure A1 in the appendix, our inventory investment series based on firm data are highly correlated with aggregate manufacturing inventory investment.)

Figures 1 and 2 reveal important features of the time-series characteristics of our data. First, the inventory investment series for small firms

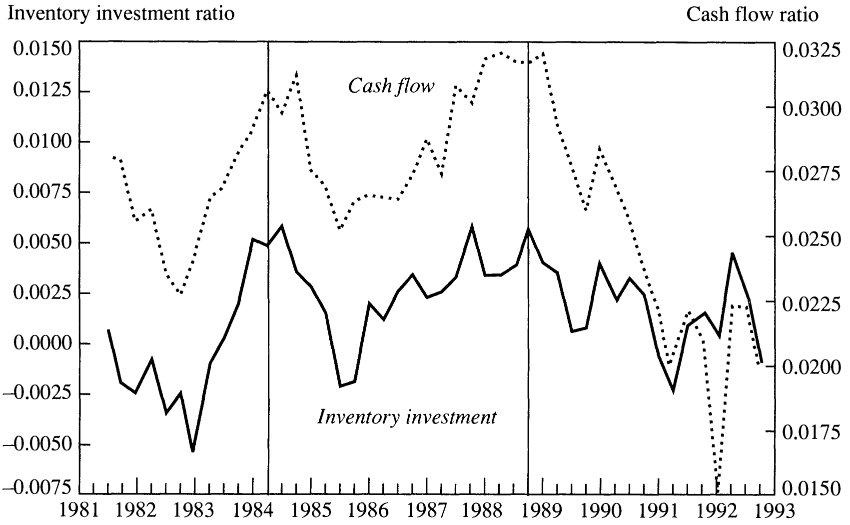
Figure 1. Inventory Investment and Cash Flow Ratios for Small Firms[a]



Source: Authors' calculations using Compustat data.

a. Inventory investment and cash flow are divided by beginning-of-period total assets. Data are seasonally adjusted with quarterly dummy variables. Vertical lines represent period boundaries.

Figure 2. Inventory Investment and Cash Flow Ratios for Large Firms[a]



Source: Authors' calculations using Compustat data.

a. Inventory investment and cash flow are divided by beginning-of-period total assets. Data are seasonally adjusted with quarterly dummy variables. Vertical lines represent period boundaries.

and large firms move together quite closely; the correlation between the two investment series is 0.73. Second, the inventory investment of small firms appears to be more volatile over the business cycle than that of large firms. Finally, and most important, for both plots, there is a close correspondence between inventory investment and cash flow; the correlations are 0.75 for small firms and 0.56 for large firms.

Figures 1 and 2 also highlight several interesting macro episodes during the sample period. In the recovery from the 1982 recession, the trough-to-peak increase in inventory investment is one-third larger for small firms, even though their cash flow increased by less than that of large firms. We might expect this pattern if small firms increased inventory investment not only to meet higher sales but also to replenish stocks drawn down to release internal finance during the previous recession. For both small and large firms, there is a sharp decline in cash flow and inventory investment during 1985, which also occurs in U.S. aggregate data. Once again, the movement in inventory investment is greater for small firms than for large firms. Finally, in the last period, cash flow peaks in late 1988 and then declines sharply. In contrast to the first two periods, the fall in inventory investment for large firms is modest compared with the decline in cash flow, a fact that is reflected in the regression results reported in the next section.

Also note that the means of inventory investment are often negative for both small and large firms. For large firms, there are quarters of inventory disinvestment at the troughs of each cyclical period in the data. Inventory disinvestment was prolonged and deep during the 1981–82 recession, especially in comparison with the 1990–91 recession.

Summary Statistics for the Regression Variables

Tables 2 and 3 report means and within-firm standard deviations for the key variables used in our regressions, by firm size and period. The construction of all variables, including the adjustment to inventories for LIFO (last in, first out) and FIFO (first in, first out) accounting, is described in the data appendix. All variables are flows, with the exception of the stock of inventories, and they are all scaled by beginning-of-quarter total assets. The mean inventory investment ratio reported in table 2 is substantially greater for small firms than for large firms in periods 1 and 2, which is consistent with the fact that small firms' sales are grow-

Table 2. Sample Means of Regression Variables

	1981:1–1984:1		*1984:2–1988:3*		*1988:4–1991:4*	
Variable[a]	*Small firms*	*Large firms*	*Small firms*	*Large firms*	*Small firms*	*Large firms*
Inventory investment ($\Delta N_t/TA_t$)	0.0020	−0.0009	0.0051	0.0026	0.0017	0.0018
Stock of inventories (N_t/TA_t)	0.2860	0.2095	0.2653	0.1919	0.2513	0.1805
Cash flow (CF_t/TA_t)	0.0221	0.0262	0.0226	0.0286	0.0207	0.0243
Sales (S_t/TA_t)	0.4172	0.3602	0.3526	0.3235	0.3198	0.2887

Source: Authors' calculations from Compustat data.
a. Each variable has been divided by the firm's beginning-of-quarter total assets.

ing faster. The cash flow ratio is somewhat greater for large firms than for small firms. Note that since cash flow is quarterly and we scale it by total assets, the ratios are smaller than those reported in studies of fixed investment with annual data scaled by the fixed capital stock.

Two further observations from table 2 are relevant to the linkage between internal finance and inventory investment. First, inventory stocks are, on average, 27 percent of total assets for small firms and 19 percent of total assets for large firms. Over all firms, inventories average nearly ten times quarterly cash flows, which means that firms can offset large negative cash flow shocks with relatively small reductions in inventory stocks. For example, for the typical firm, a single quarterly decline of 50 percent in cash flow could be offset by a 5 percent reduction in the stock of inventories. Second, across the three time periods, the ratio of the stock of inventories to total assets has declined for both small

Table 3. Within-Firm Standard Deviations of Regression Variables

	1981:1–1984:1		*1984:2–1988:3*		*1988:4–1991:4*	
Variable[a]	*Small firms*	*Large firms*	*Small firms*	*Large firms*	*Small firms*	*Large firms*
Inventory investment ($\Delta N_t/TA_t$)	0.0227	0.0148	0.0253	0.0172	0.0252	0.0168
Cash flow (CF_t/TA_t)	0.0121	0.0103	0.0165	0.0140	0.0193	0.0158
Sales (S_t/TA_t)	0.0481	0.0356	0.0507	0.0421	0.0448	0.0366

Source: Authors' calculations from Compustat data.
a. Each variable has been divided by the firm's beginning-of-quarter total assets.

and large firms.[47] Under our hypothesis, the role of inventories as a source of liquidity, and therefore as a potential shock absorber, has diminished.

Table 3 presents the within-firm standard deviations of inventory investment, cash flow, and sales. Inventory investment is substantially more volatile for small firms; the standard deviation is about 50 percent larger.[48] Cash flow is also more volatile for small firms, but the difference between large and small firms is not nearly as great as that for inventory investment. The ratio of the standard deviation of inventory investment to the standard deviation of cash flow (averaged over the three periods) is 1.57 for small firms and 1.24 for large firms. The fact that for small firms inventory investment is more volatile, relative to cash flow, is consistent with the financing-constraint hypothesis: for any given fluctuation in internal finance, small firms should exhibit a greater inventory response.

Regression Results

This section presents results from estimating several versions of equation 4. We also discuss results from instrumental variables estimation, specifications that account for short-term debt and cash stocks as possible sources of inventory finance, and results obtained by splitting the data according to firms' bond ratings.

Primary Specification

Tables 4 and 5 report the main regression results for the specification given by equation 4. All regressions include fixed firm effects that eliminate the influence of differences in the average levels of the regressors across firms; in other words, all remaining variation is in the time dimension of the data. The standard errors are corrected for heteroscedasticity by White's method, and the degrees of freedom are adjusted to account for the implicit firm and time dummies in the regressions. Each table

47. This decline is consistent with "just-in-time" inventory management practices. It is mirrored in the *QFR* aggregate data for manufacturing firms. Similar trends are documented by Morgan (1991) and Kopcke (1993).

48. This finding is consistent with those emphasized by Gertler and Gilchrist (1994).

Table 4. Regressions of Inventory Investment with Quarter Dummies[a]

Sample period and independent variable[b]	*Small firms* Coefficient	*Small firms* Standard error	*Large firms* Coefficient	*Large firms* Standard error
Period 1, 1981:3–1984:1				
Lagged inventory (N_{t-1}/TA_t)	−0.235	0.025	−0.236	0.032
Sales (S_t/TA_t)	−0.054	0.015	0.004	0.017
(S_{t-1}/TA_{t-1})	0.046	0.016	0.029	0.017
(S_{t-2}/TA_{t-2})	0.035	0.015	0.037	0.015
Cash flow (CF_t/TA_t)	0.173	0.058	0.129	0.044
(CF_t/TA_{t-1})	0.154	0.061	0.131	0.041
(CF_{t-2}/TA_{t-2})	0.101	0.062	−0.033	0.041
Sum of cash flow effects	0.428	0.080	0.227	0.061
Adjusted R^2	0.434	. . .	0.335	. . .
Period 2, 1984:2–1988:3				
Lagged inventory (N_{t-1}/TA_t)	−0.154	0.011	−0.134	0.017
Sales (S_t/TA_t)	−0.061	0.011	0.013	0.014
(S_{t-1}/TA_{t-1})	0.078	0.010	0.056	0.013
(S_{t-2}/TA_{t-2})	0.033	0.009	−0.013	0.011
Cash flow (CF_t/TA_t)	0.166	0.024	0.068	0.028
(CF_{t-1}/TA_{t-1})	0.031	0.022	0.079	0.025
(CF_{t-2}/TA_{t-2})	0.068	0.023	0.058	0.020
Sum of cash flow effects	0.265	0.033	0.205	0.038
Adjusted R^2	0.345	. . .	0.346	. . .
Period 3, 1988:4–1992:4				
Lagged inventory (N_{t-1}/TA_t)	−0.187	0.011	−0.208	0.020
Sales (S_t/TA_t)	−0.070	0.010	0.016	0.015
(S_{t-1}/TA_{t-1})	0.087	0.010	0.058	0.015
(S_{t-2}/TA_{t-2})	0.041	0.009	0.038	0.014
Cash flow (CF_t/TA_t)	0.151	0.019	0.016	0.019
(CF_{t-1}/TA_{t-1})	0.028	0.018	0.004	0.017
(CF_{t-2}/TA_{t-2})	0.020	0.018	−0.006	0.018
Sum of cash flow effects	0.199	0.027	0.014	0.029
Adjusted R^2	0.256	. . .	0.354	. . .

Source: Authors' regressions using Compustat data.

a. The dependent variable is inventory investment (N_t/TA_t). All equations are estimated with fixed firm effects. Quarter dummies are included for each four-digit SIC industry, as described in the text. Standard errors are corrected for heteroscedasticity using White's method. Standard errors are also corrected for degrees of freedom lost due to the dummy variables. The adjusted R^2 statistics exclude variance explained by the fixed firm effects.

b. Each variable has been divided by the appropriately lagged total assets.

Table 5. Regressions of Inventory Investment with Time Dummies[a]

Sample period and independent variable[b]	Small firms: Coefficient	Small firms: Standard error	Large firms: Coefficient	Large firms: Standard error
Period 1, 1981:3–1984:1				
Lagged inventory (N_{t-1}/TA_t)	−0.271	0.047	−0.304	0.064
Sales (S_t/TA_t)	−0.085	0.025	−0.035	0.029
(S_{t-1}/TA_{t-1})	0.027	0.025	0.017	0.023
(S_{t-2}/TA_{t-2})	0.065	0.025	0.060	0.019
Cash flow (CF_t/TA_t)	0.087	0.093	0.104	0.067
(CF_{t-1}/TA_{t-1})	0.092	0.094	0.098	0.058
(CF_{t-2}/TA_{t-2})	0.077	0.096	−0.108	0.058
Sum of cash flow effects	0.256	0.152	0.094	0.088
Adjusted R^2	0.227	...	0.216	...
Period 2, 1984:2–1988:3				
Lagged inventory (N_{t-1}/TA_t)	−0.161	0.015	−0.134	0.023
Sales (S_t/TA_t)	−0.075	0.014	−0.015	0.019
(S_{t-1}/TA_{t-1})	0.075	0.013	0.046	0.018
(S_{t-2}/TA_{t-2})	0.037	0.013	0.024	0.015
Cash flow (CF_t/TA_t)	0.155	0.034	0.084	0.041
(CF_{t-1}/TA_{t-1})	0.029	0.031	0.072	0.035
(CF_{t-2}/TA_{t-2})	0.048	0.032	0.033	0.029
Sum of cash flow effects	0.232	0.049	0.189	0.057
Adjusted R^2	0.278	...	0.300	...
Period 3, 1988:4–1992:4				
Lagged inventory (N_{t-1}/TA_t)	−0.196	0.013	−0.295	0.031
Sales (S_t/TA_t)	−0.083	0.012	0.020	0.023
(S_{t-1}/TA_{t-1})	0.081	0.011	0.060	0.021
(S_{t-2}/TA_{t-2})	0.046	0.010	0.052	0.021
Cash flow (CF_t/TA_t)	0.155	0.024	−0.015	0.028
(CF_{t-1}/TA_{t-1})	0.020	0.022	−0.018	0.025
(CF_{t-2}/TA_{t-2})	0.010	0.022	−0.021	0.026
Sum of cash flow effects	0.185	0.034	−0.054	0.043
Adjusted R^2	0.244	...	0.339	...

Source: Authors' calculations from Compustat data.

a. The dependent variable is inventory investment (N_t/TA_t). All equations are estimated with fixed firm effects. Time dummies are included for each four-digit SIC industry, as described in the text. Standard errors are corrected for heteroscedasticity using White's method. Standard errors are also corrected for degrees of freedom lost due to the dummy variables. The adjusted R^2 statistics exclude variance explained by the fixed firm effects.

b. Each variable has been divided by the appropriately lagged total assets.

contains results for the three time periods, as well as separate regressions for small and large firms. The regressions in table 4 differ from those in table 5 only in their treatment of fixed time effects. In table 4, the regressions include quarter dummies for each four-digit SIC industry to control for seasonality. In table 5, the regressions include a more general set of four-digit SIC dummies each defined for each time period in the data (that is, a separate dummy for each possible year-quarter combination in each four-digit industry). As discussed earlier, these time dummies control for all time-varying effects at the industry level or at higher levels of aggregation. But they also remove the common cyclical component of inventory investment, cash flow, and sales for each four-digit industry. Therefore, the results in table 5 may be interpreted as an extreme test of our hypothesis when idiosyncratic firm variation alone, independent of cyclical industry movements, is used to estimate the coefficients.

In tables 4 and 5, the coefficients on lagged inventory stock variable are always negative and highly significant. The estimated speeds of adjustment from the actual to the desired inventory stock, ranging from 13 to 30 percent a quarter, are consistent with other estimates in the literature.[49] Omitting the fixed firm effects has a large influence on the results (not shown), reducing the adjustment speed dramatically. (The point estimates range from 1.5 to 4.2 percent a quarter.) This outcome demonstrates the importance of controlling for fixed firm effects. For small firms, we obtain negative and significant contemporaneous sales effects in all regressions in tables 4 and 5, which suggest the presence of buffer-stock effects. For large firms, the evidence is mixed, with negative buffer-stock coefficients only in table 5 and only for periods 1 and 2. When cash flow is excluded from the regression (not shown), these coefficients increase, on average, by about 50 percent. Thus, it is likely that excluding cash flow may be partially responsible for the fact that studies in the inventory literature often fail to find any negative effects of unan-

49. We estimate speeds of adjustment comparable with other studies despite two disadvantages of our data for this purpose. First, although time aggregation can lower adjustment speeds, we obtain estimates with quarterly firm data that are broadly consistent with those obtained from monthly industry data. Second, as Blinder (1986a) finds, combining finished goods, work-in-process, and raw-materials inventories is likely to lower estimated adjustment speeds. But our results for total inventories are not much different from those obtained for finished goods stocks alone.

ticipated sales movements on inventory investment.[50] All but one of the lagged sales coefficients are positive, consistent with a positive accelerator effect for inventories.

The main focus of our study is the cash flow effect. Consistent with the financing-constraint hypothesis, the sum of the cash flow coefficients, and many of the individual coefficients, are positive and significant in all of the regressions presented in tables 4 and 5, except for large firms in period 3.[51] The only major difference in the cash flow results between tables 4 and 5 occurs in period 1, which we discuss below. For small firms, the sums of the cash flow coefficients are economically important in all three periods (sums ranging from 0.185 to 0.428). The cash flow sums for large firms are also positive in the first two periods. Thus, a substantial fraction of the quarter-to-quarter variation in cash flow is reflected in inventory changes, even though inventory accumulation constitutes a very small net use of funds over the long horizon (see table 2). This finding is consistent with our argument that inventory adjustment is a relatively low-cost way for financially constrained firms to respond to temporary cash flow shocks.[52]

The differences in the cash flow effects between large and small firms support the view that inventory investment is affected by financing constraints. As discussed previously, small firms are likely to face tighter financing constraints, and we therefore expect that the effect of cash flow shocks on inventory investment should be greater for small firms. This result occurs for the sum of the cash flow coefficients in all of our regressions, and the difference is statistically significant in periods 1 and 3.

As discussed previously, the different cash flow effects across those categories of firms that are presumed to have different access to financial

50. See, for example, Blinder (1986a).

51. When an additional lag of cash flow was included in the regressions, it was insignificant and had virtually no effect on the cash flow sums. The standard errors for the cash flow sums are large in table 5 (period 1) because of the degrees of freedom lost from the large number of time dummies relative to the sample size. Nevertheless a χ^2 test based on the asymptotically efficient covariance matrix rejects the null hypothesis that the cash flow sums are zero in these regressions at a 1 percent significance level for small firms and a 6 percent level for large firms.

52. The magnitude of the coefficients is similar to estimates of the impact of cash flow on fixed investment (Fazzari, Hubbard, and Petersen, 1988, for example) even though average inventory investment is much smaller than fixed investment. Therefore, inventory investment appears to be disproportionately sensitive to cash flow, compared with fixed investment.

markets are important evidence that cash flow does not simply proxy for expectations about future investment opportunities. To further examine the question of expectations, we added to equation 4 two different sets of variables—stock price growth and leads of sales—that explicitly relate to expectations. The results (not shown) have two interesting features. First, the coefficients on these variables are consistent with their role as measures of expectations. The stock-price variables (contemporaneous and two lagged values) have positive and significant coefficients in 8 of the 12 regressions corresponding to tables 4 and 5. The one-quarter lead of sales is important in all of the regressions with *t*-statistics ranging from four to more than ten; a two-quarter lead had little effect. Second, and most important, including these expectational proxies has virtually no effect on the cash flow results.[53] These results lend further support to our interpretation of the cash flow effects as indicators of financing constraints on inventory investment.

Our finding of economically important cash flow effects for large firms in periods 1 and 2, and the robustness of this finding when a variety of additional expectational proxies were included in the regression, suggests a role for financing constraints in the inventory behavior of even large firms, helping to establish the importance of financing constraints for the aggregate cyclical behavior of inventory investment. To further explore the cash flow effect for large firms, we increased the cutoff size for large firms from $300 million in assets to $1 billion. The cash flow sums for this subsample (not shown) are somewhat lower than those reported in both tables 4 and 5 for large firms, but the effect remains significant in periods 1 and 2.[54] Increasing the cutoff beyond $1 billion did not reduce the cash flow sums further, indicating that some positive financing effect remains even for very large firms. These results are consistent with the fact that most large firms do not have access to publicly

53. In regressions with quarter dummies (as in table 4), the cash flow sums for small firms with leads of sales in the regressions are 0.379, 0.298, and 0.218 for periods 1–3. The corresponding sums for large firms are 0.266, 0.222, and 0.015. With stock price growth variables in the regressions, the small-firm cash flow sums are 0.331, 0.266, and 0.183 and the large-firm sums are 0.220, 0.212, and 0.016. Further details and results corresponding to table 5 are available from the authors.

54. The cash flow sums for regressions that correspond to those in table 4 are 0.186, 0.152, and −0.006 for periods 1, 2, and 3 respectively, and the difference of the sums between small firms and those with more than $1 billion in assets is statistically significant in all three periods. Averaged across the three periods, these coefficients declined by 26 percent compared with the large-firm sample analyzed in table 4. The sums corresponding to table 5 are 0.086, 0.106, and −0.051, which amounts to an average decline of 38 percent.

traded short-term debt (commercial-paper programs) and many do not have bond ratings.

The relative magnitudes of the cash flow coefficients over the three time periods are also of interest and lend support to the financing-constraint hypothesis.[55] In the first panel of table 4, which covers the 1981–82 recession, the cash flow coefficients are large for both size classes. These results are consistent with the pronounced decline in aggregate inventory investment during the 1981–82 recession. Such a decline could probably occur only if large firms made major cuts in inventory investment. This was also a period of very tight money, when credit rationing could have been severe even for large firms.

The second period includes the economic slowdown in 1985–86. Aggregate cash flow and inventory investment in these two years were lower than in the immediately preceding and following years, although the reductions were not as dramatic as those in the earlier recession. Nevertheless, the aggregate decline in manufacturing inventory investment as a percentage of the decline in manufacturing cash flow was larger during this slowdown than during the early 1980s. Thus, it is not surprising to find significant cash flow effects for this period.

In the third period, the cash flow coefficients for large firms are small in tables 4 and 5. Again, this result is consistent with the historical record. Aggregate reductions in inventory investment during the 1990–91 recession, compared with those during the 1981–82 recession, were smaller and more spread out, although cash flow declined dramatically. In addition, aggregate inventory stocks were lower entering the 1990–91 recession, which might reduce the extent to which optimizing firms cut inventories to respond to reductions in cash flow. We discuss these macroeconomic issues in more depth in the next section.

Our results are largely the same whether one looks at regressions that include only quarter dummies (table 4) or regressions that include a full set of time dummies (table 5). For periods 2 and 3, the coefficients in ta-

55. Because our sample varies across periods, we checked the pattern of the cash flow effects across time by examining a sample of firms balanced across the full period (1981:3 to 1992:4). In this sample, the cash flow sums have the same pattern across time as reported in tables 4 and 5 for both small and large firms. The differences in the sums between the small and large firms are approximately the same. Finally, when we pooled the three time periods for this balanced sample, the cash flow coefficients fall between the coefficients estimated for the three periods separately: 0.240 for small firms and 0.140 for large firms.

bles 4 and 5 are very similar. For period 1, the cash flow sums are smaller in table 5 than they are in table 4. The standard errors, corrected for the lost degrees of freedom, are larger in table 5 than in table 4 because of the much larger set of time dummies. The decline in the cash flow coefficients is not surprising because the additional time dummies remove all the cyclical variation in cash flow common to firms in each four-digit industry. Because period 1 contains the sharp cyclical episode of the early 1980s, it is likely that common cash flow variation at the four-digit level dominates idiosyncratic cash flow variation for this period. With less variation to identify the cash flow effect, measurement errors may become more severe, pushing the cash flow coefficients downward. The important point is that the cash flow effects remain strong, especially for small firms, even in the rather extreme experiment that attributes *all* of the time-series variation at the industry level to factors other than cash flow.

To explore whether the differences between the size of the cash flow effects in period 1 are due to cost shocks, we ran some additional regressions. We included the first differences of explicit cost measures—interest rates, wages, and energy costs—in regressions with dummy variables as defined in table 4.[56] The most interesting effects were obtained for the energy cost variable in period 1. It has a negative and significant coefficient in the small-firm regression. (Its coefficient is insignificant for large firms.) The coefficients on the interest rate are usually positive but insignificant. Including these three cost variables in the regression lowers the cash flow sum for small firms to 0.382 from 0.428. The change for large firms is negligible, with the sum falling from 0.227 to 0.224. Including the explicit cost variables has no effect on the cash flow results in any of the regressions for period 2 or 3. Thus, it does not appear that cost shocks account for much of the difference between the cash flow coefficients reported in tables 4 and 5 for period 1.

Instrumental Variables Results

In the literature on cash flow and fixed investment, researchers have been concerned about the endogeneity of contemporaneous cash flow.

56. The wage and energy data were disaggregated to the two-digit SIC level. The interest rate was the three-month Treasury bill rate less actual inflation measured by the GDP deflator.

This concern is mitigated in our context for several reasons. First, with high-frequency data it is less likely that the returns generated by contemporaneous investment will affect contemporaneous cash flow. Second, the most likely source for a correlation between cash flow and shocks to inventory investment is unanticipated sales movements, for which we control. Third, although technological or cost shocks might generate a correlation between cash flow and shocks to inventory investment, we can control for industry-level cost shocks with time dummies. Moreover, the evidence presented above suggests that cost shocks are not particularly important for our cash flow results.

To check the robustness of the inventory–cash flow link, however, we also ran the regressions with an instrumental variables procedure that has been used in the financing-constraint literature.[57] For this purpose, only contemporaneous cash flow enters the model, permitting the use of cash flow lags as instruments.[58] Results from this procedure are presented in table 6. Because of the quarterly frequency of the data, seasonality must be treated carefully when using lagged cash flow as an instrument for contemporaneous cash flow. Therefore, the instrumental variable regressions are estimated with quarter dummies defined at the firm level.[59]

In table 6, the coefficients on lagged inventory stock and sales are similar to those obtained from the ordinary least squares regressions. One exception is that the coefficient on the second lag of sales is near zero and insignificant in most of the regressions, suggesting that it is the contemporaneous first difference of sales that matters for inventory investment, especially for small firms. The point estimates of the cash flow effects increase in every regression when compared with the results in table 4, and their standard errors are higher. The cash flow effects remain

57. See, for example, Himmelberg and Petersen (1994) and Kashyap, Lamont, and Stein (1994).

58. The coefficients on the lags of cash flow in the first-stage regression for contemporaneous cash flow are consistent from period to period. For small firms, the coefficients on the first lag of cash flow are 0.353, 0.288, and 0.275 in periods 1–3. The coefficients for the second lag are 0.133, 0.089, and 0.097. For large firms, the coefficients on the first lag of cash flow are 0.274, 0.259, and 0.185; the second-lag coefficients are 0.232, 0.092, and 0.104. The first-stage R^2s for small firms range from 0.28 to 0.37 and those for large firms range from 0.20 to 0.33.

59. When the instrumental variables regressions are estimated with four-digit industry dummies, the coefficients are quite similar but the standard errors for cash flow rise by about 60 percent. This finding is consistent with the view that lagged cash flow is a better instrument with seasonal adjustment at the firm level.

Table 6. Instrumental Variable Regressions of Inventory Investment[a]

Sample period and independent variable[b]	*Small firms*		*Large firms*	
	Coefficient	*Standard error*	*Coefficient*	*Standard error*
Period 1, 1981:3–1984:1				
Lagged inventory stock (N_{t-1}/TA_t)	−0.170	0.023	−0.147	0.027
Sales (S_t/TA_t)	−0.077	0.022	−0.023	0.020
(S_{t-1}/TA_{t-1})	0.106	0.021	0.029	0.022
(S_{t-2}/TA_{t-2})	−0.011	0.016	−0.008	0.016
Cash flow (CF_t/TA_t), instrumented	0.651	0.132	0.411	0.093
Period 2, 1984:2–1988:3				
Lagged inventory stock (N_{t-1}/TA_t)	−0.111	0.011	−0.078	0.016
Sales (S_t/TA_t)	−0.065	0.014	−0.011	0.019
(S_{t-1}/TA_{t-1})	0.077	0.012	0.050	0.019
(S_{t-2}/TA_{t-2})	0.015	0.010	−0.039	0.012
Cash flow (CF_t/TA_t), instrumented	0.439	0.066	0.471	0.087
Period 3, 1988:4–1992:4				
Lagged inventory stock (N_{t-1}/TA_t)	−0.127	0.011	−0.099	0.018
Sales (S_t/TA_t)	−0.077	0.014	0.043	0.018
(S_{t-1}/TA_{t-1})	0.086	0.011	0.033	0.015
(S_{t-2}/TA_{t-2})	0.021	0.010	−0.003	0.012
Cash flow (CF_t/TA_t), instrumented	0.398	0.054	0.134	0.068

Source: Authors' calculations from Compustat data.

a. The dependent variable is inventory investment (N_t/TA_t). Regressions were estimated with instrumental variables as described in the text. The regressions included fixed firm effects and separate quarter dummies for each firm. Standard errors in parentheses are corrected for degrees of freedom lost due to the dummy variables and for heteroscedasticity using White's method.

b. Each variable has been divided by the appropriately lagged total assets.

significantly different from zero for all the regressions (with asymptotic t-statistics ranging from 4.4 to 7.4), except for large firms in the third period, when cash flow is marginally significant. The pattern of coefficients across the three panels is similar to the ordinary least squares results in table 4. The difference between large and small firms remains significant in both the first and third periods. Overall, the instrumental variables results strongly confirm the economic importance of cash flow for inventory investment across firm size and time.

Balance Sheet Effects and Alternative Sources of Finance

Because of the importance of internal finance and its great volatility over the cycle, we have been focusing on the effect of the *flow* of internal finance on inventory investment. Our work would be incomplete, however, if we did not consider the extent to which firms can use alternative sources of finance to partially offset fluctuations in the flow of internal finance. Some large firms have access to publicly traded debt, and surely most firms can obtain some bank debt. New short-term debt might be used to offset fluctuations in internal finance. Even if firm financing is rationed in credit markets, firms still may be able to partially insulate themselves from internal-finance fluctuations by drawing down stocks of cash when cash flow declines and replenishing those stocks when cash flow recovers.

To measure the possible effect of changes in cash stocks as a source of finance for inventory investment, we include the change of cash and equivalents in the regression. The change of debt in current liabilities proxies for firms' new short-term debt issues.[60] Because these variables are endogenous, the equation is estimated with instrumental variables. We use the beginning-of-period stock of cash and the stock of debt in current liabilities as instruments.[61] The rationale for these instruments is that the change in cash or short-term debt over a period will be related to the level of its beginning-of-period stock (as in a stock-adjustment model).

The results appear in table 7 for the model estimated with quarter dummies at the four-digit SIC level. Similar results were obtained (not shown) with the full set of time dummies. The coefficient on the change in cash and equivalents is negative and significant in all three periods for large firms. The magnitude of the coefficient is also quite stable across periods for large firms. This negative sign is expected if firms face financing constraints and draw down stocks of cash to finance inventory investment. For small firms, the change in cash is significant only in the first period. When the change in short-term debt is significant in table 7, it has a positive coefficient (for large firms in period 1, for small firms in periods 2 and 3). If firms face financing constraints, we would expect access to debt to increase their ability to finance all components of investment, inventories in particular. For our purposes, the most im-

60. Compustat does not provide a separate variable for short-term debt alone. We also tried another variable to measure the stock of short-term liquidity, defined as cash plus accounts receivable less accounts payable. This measure has small and insignificant coefficients in every regression.

61. This is the approach taken in Fazzari and Petersen (1993).

Table 7. Regressions of Inventory Investment with Alternative Sources of Funds[a]

Sample period and independent variable[b]	Small firms: Coefficient	Small firms: Standard error	Large firms: Coefficient	Large firms: Standard error
Period 1, 1981:3–1984:1				
Lagged inventory stock (N_{t-1}/TA_t)	−0.183	0.022	−0.183	0.030
Sales (S_t/TA_t)	−0.030	0.019	0.054	0.019
(S_{t-1}/TA_{t-1})	0.091	0.021	0.024	0.022
(S_{t-2}/TA_{t-2})	−0.008	0.019	−0.009	0.019
Cash flow (CF_t/TA_t)	0.270	0.060	0.155	0.047
(CF_{t-1}/TA_{t-1})	0.166	0.065	0.108	0.044
(CF_{t-2}/TA_{t-2})	0.035	0.068	0.024	0.048
Sum of cash flow effects	0.471	0.074	0.287	0.053
Change in short-term debt	−0.012	0.074	0.111	0.050
Change in cash and equivalents	−0.130	0.070	−0.126	0.062
Period 2, 1984:2–1988:3				
Lagged inventory stock (N_{t-1}/TA_t)	−0.127	0.011	−0.097	0.015
Sales (S_t/TA_t)	−0.027	0.012	0.070	0.017
(S_{t-1}/TA_{t-1})	0.075	0.012	0.026	0.019
(S_{t-2}/TA_{t-2})	0.002	0.010	−0.039	0.012
Cash flow (CF_t/TA_t)	0.157	0.027	0.075	0.028
(CF_{t-1}/TA_{t-1})	0.045	0.023	0.097	0.025
(CF_{t-2}/TA_{t-2})	0.092	0.023	0.059	0.020
Sum of cash flow effects	0.294	0.031	0.231	0.034
Change in short-term debt	0.095	0.029	−0.032	0.039
Change in cash and equivalents	0.018	0.024	−0.114	0.040
Period 3, 1988:4–1992:4				
Lagged inventory stock (N_{t-1}/TA_t)	−0.143	0.008	−0.101	0.016
Sales (S_t/TA_t)	−0.027	0.009	0.061	0.015
(S_{t-1}/TA_{t-1})	0.085	0.010	0.025	0.016
(S_{t-2}/TA_{t-2})	0.013	0.008	0.002	0.012
Cash flow (CF_t/TA_t)	0.136	0.016	0.060	0.017
(CF_{t-1}/TA_{t-1})	0.064	0.017	0.026	0.016
(CF_{t-2}/TA_{t-2})	0.034	0.016	−0.027	0.015
Sum of cash flow effects	0.214	0.032	0.059	0.024
Change in short-term debt	0.044	0.018	0.010	0.011
Change in cash and equivalents	−0.016	0.023	−0.119	0.028

Source: Authors' calculations from Compustat data.

a. The dependent variable is inventory investment (N_t/TA_t). Regressions are estimated with instrumental variables as described in the text. Time and firm dummies are included as described in the note to table 4. Standard errors in parentheses are corrected for degrees of freedom lost due to the dummy variables and for heteroscedasticity using White's method.

b. Each variable has been divided by the appropriately lagged total assets.

portant result in table 7 is that the cash flow effects remain statistically and economically strong even after accounting for other sources of short-term finance.

The ability of a firm to offset declines in cash flow can also be measured by the stocks of debt and cash on its balance sheet. Recent research has raised concerns that an increase in leverage has weakened firms' balance sheets.[62] High leverage, other things equal, might reduce the ability of firms to finance inventory investment with new debt. Similarly, as noted above, cash stocks can provide liquidity for financing inventory investment. To account for these balance sheet effects, we add cash and short-term debt stocks to our primary specification and report the results in table 8. The debt variable has the expected negative coefficient in five of the six regressions and is statistically significant in four instances. The cash stock has the expected positive coefficient in four of the regressions. Again, including these financial stock variables has little effect on the cash flow results, as compared with table 4.

We also considered how changes in accounts receivable and accounts payable affect the cash flow results. Like inventories, these entries on the balance sheet may be important uses and sources of internal finance and liquidity. Firms that face financing constraints may offer less generous terms of payment, thereby reducing accounts receivable and conserving internal finance. Likewise, stretching out payments to suppliers will conserve internal finance in the short run. We modified the specification in equation 4 by including contemporaneous and two lagged values of the changes in both accounts receivable and accounts payable in the regressions. Although these variables were typically significant in the regressions (not shown), their inclusion had little impact on the cash flow coefficients.

Sample Split by Bond Ratings

We have focused on differences in firm size to examine the heterogeneity of finance effects. To check the robustness of our findings, we also use the lack of a bond rating as a proxy for the presence of financing constraints.[63] Table 9 presents regression results with the sample divided

62. See, for example, Friedman (1986) and Bernanke and Campbell (1988).

63. Whited (1992) and Kashyap, Lamont, and Stein (1994) have argued that the existence of a bond rating is a good indicator of access to finance.

Table 8. Regressions of Inventory Investment with Balance Sheet Stocks[a]

Sample period and independent variable[b]	*Small firms* Coefficient	*Small firms* Standard error	*Large firms* Coefficient	*Large firms* Standard error
Period 1, 1981:3–1984:1				
Lagged inventory stock (N_{t-1}/TA_t)	−0.220	0.027	−0.217	0.036
Sales (S_t/TA_t)	−0.048	0.016	0.010	0.018
(S_{t-1}/TA_{t-1})	0.046	0.017	0.029	0.017
(S_{t-2}/TA_{t-2})	0.040	0.016	0.039	0.016
Cash flow (CF_t/TA_t)	0.160	0.058	0.115	0.047
(CF_{t-1}/TA_{t-1})	0.149	0.063	0.127	0.043
(CF_{t-2}/TA_{t-2})	0.081	0.064	−0.051	0.044
Sum of cash flow effects	0.392	0.087	0.191	0.064
Stock of debt	−0.009	0.023	−0.048	0.015
Stock of cash	0.025	0.016	0.033	0.017
Period 2, 1984:2–1988:3				
Lagged inventory stock (N_{t-1}/TA_t)	−0.146	0.011	−0.139	0.018
Sales (S_t/TA_t)	−0.066	0.011	0.014	0.014
(S_{t-1}/TA_{t-1})	0.077	0.010	0.053	0.013
(S_{t-2}/TA_{t-2})	0.032	0.010	−0.010	0.011
Cash flow (CF_t/TA_t)	0.170	0.025	0.064	0.028
(CF_{t-1}/TA_{t-1})	0.031	0.023	0.082	0.025
(CF_{t-2}/TA_{t-2})	0.056	0.024	0.059	0.020
Sum of cash flow effects	0.257	0.034	0.205	0.037
Stock of debt	−0.042	0.011	0.007	0.014
Stock of cash	−0.004	0.005	0.017	0.008
Period 3, 1988:4–1992:4				
Lagged inventory stock (N_{t-1}/TA_t)	−0.186	0.011	−0.202	0.020
Sales (S_t/TA_t)	−0.071	0.010	0.016	0.015
(S_{t-1}/TA_{t-1})	0.087	0.010	0.058	0.015
(S_{t-2}/TA_{t-2})	0.039	0.009	0.037	0.014
Cash flow (CF_t/TA_t)	0.150	0.020	0.012	0.019
(CF_{t-1}/TA_{t-1})	0.025	0.018	−0.004	0.018
(CF_{t-2}/TA_{t-2})	0.015	0.019	−0.011	0.018
Sum of cash flow effects	0.190	0.028	−0.003	0.030
Stock of debt	−0.022	0.006	−0.007	0.003
Stock of cash	−0.004	0.004	0.014	0.008

Source: Authors' calculations from Compustat data.

a. The dependent variable is inventory investment (N_t/TA_t). Time and firm dummies are included as described in the note to table 4. Standard errors in parentheses are corrected for degrees of freedom lost due to the dummy variables and for heteroscedasticity using White's method.

b. Each variable has been divided by the appropriately lagged total assets.

Table 9. Regressions of Inventory Investment with Data Split by Bond Rating[a]

Sample period and independent variable[b]	*Firms without S&P bond rating* Coefficient	Standard error	*Firms with S&P bond rating* Coefficient	Standard error
Period 1, 1981:3–1984:1				
Lagged inventory (N_{t-1}/TA_t)	−0.234	0.025	−0.269	0.026
Sales (S_t/TA_t)	−0.041	0.015	−0.004	0.017
(S_{t-1}/TA_{t-1})	0.031	0.015	0.072	0.019
(S_{t-2}/TA_{t-2})	0.043	0.014	0.025	0.016
Cash flow (CF_t/TA_t)	0.127	0.052	0.196	0.041
(CF_{t-1}/TA_{t-1})	0.110	0.053	0.103	0.039
(CF_{t-2}/TA_{t-2})	0.088	0.052	−0.077	0.048
Sum of cash flow effects	0.325	0.075	0.222	0.070
Adjusted R^2	0.386	...	0.509	...
Period 2, 1984:2–1988:3				
Lagged inventory (N_{t-1}/TA_t)	−0.177	0.012	−0.109	0.017
Sales (S_t/TA_t)	−0.055	0.011	0.008	0.016
(S_{t-1}/TA_{t-1})	0.077	0.010	0.034	0.016
(S_{t-2}/TA_{t-2})	0.032	0.009	0.001	0.012
Cash flow (CF_t/TA_t)	0.155	0.025	0.092	0.031
(CF_{t-1}/TA_{t-1})	0.025	0.023	0.069	0.025
(CF_{t-2}/TA_{t-2})	0.074	0.023	0.020	0.021
Sum of cash flow effects	0.254	0.036	0.181	0.035
Adjusted R^2	0.338	...	0.321	...
Period 3, 1988:4–1992:4				
Lagged inventory (N_{t-1}/TA_t)	−0.205	0.012	−0.173	0.025
Sales (S_t/TA_t)	−0.057	0.010	0.006	0.019
(S_{t-1}/TA_{t-1})	0.071	0.010	0.054	0.019
(S_{t-2}/TA_{t-2})	0.046	0.009	0.047	0.015
Cash flow (CF_t/TA_t)	0.130	0.019	0.031	0.022
(CF_{t-1}/TA_{t-1})	0.011	0.018	0.011	0.020
(CF_{t-2}/TA_{t-2})	0.026	0.018	0.008	0.019
Sum of cash flow effects	0.167	0.027	0.050	0.034
Adjusted R^2	0.238	...	0.262	...

Source: Authors' calculations from Compustat data.

a. The dependent variable is inventory investment (N_t/TA_t). All equations are estimated with fixed firm effects. Quarter dummies are included for each four-digit SIC industry, as described in the text. Standard errors are corrected for heteroscedasticity using White's method. Standard errors are also corrected for degrees of freedom lost due to the dummy variables. The adjusted R^2 statistics exclude variance explained by the fixed firm effects.

b. Each variable has been divided by the appropriately lagged total assets.

according to whether a firm has or does not have a Standard & Poor's bond rating. Again, the regressions include four-digit quarter dummies to control for seasonal factors. The results were similar with the full set of time dummies. For the most part, only the largest corporations have publicly traded and rated debt, and the bond rating split reapportions the sample so that some medium and large firms are now grouped with the small firms in the no–bond rating group.[64] We find strong cash flow effects for both groups of firms in period 1, relatively smaller cash flow coefficients in period 3, and larger cash flow effects for unrated firms than for rated firms in all three periods. These results are similar to our findings from the regressions based on firm size.

Kashyap, Lamont, and Stein also use firm-level data to test for a liquidity effect on inventory investment. Their results are best compared with those in table 9 because they split their data according to the presence of a bond rating. One reason, however, why our results are not directly comparable with theirs is that they use the stock of cash and equivalents to measure liquidity rather than cash flow. With this caveat in mind, we compare the two sets of results.[65]

We find a more pervasive role for internal finance than Kashyap, Lamont, and Stein, both across time and bond-rating categories. In separate cross-sections that overlapped with our data, their measure of liquidity is significant for inventory investment only in 1982 and only for firms without bond ratings.[66] By contrast, we find economically important effects for firms without bond ratings in all periods and for bond-rated firms in periods 1 and 2. There are two likely reasons for these differences. First, our results are based on quarterly rather than annual data. Because of the flexibility of inventories discussed previously, financial effects on inventory investment may occur quickly, and therefore they may appear relatively weak at annual frequencies even if they are significant at higher frequencies. Second, Kashyap, Lamont, and Stein estimate cross-sectional regressions (between firms). By contrast,

64. This split puts 324, 510, and 670 firms in the group without bond ratings and 164, 161, and 204 firms in the group with bond ratings for periods 1, 2, and 3 respectively.

65. See Kashyap, Lamont, and Stein (1994). When the beginning-of-period cash and equivalents variable is included in our regressions along with cash flow, the cash flow coefficients are hardly affected. The stock of cash variable has a positive coefficient in most regressions but is only marginally significant. See the results in table 8.

66. Kashyap, Lamont, and Stein (1994) also report a significant liquidity effect for 1974, again only for their sample without bond ratings.

we use the time dimension of our panels (within-firm variation) to estimate internal-finance effects. The fact that we are able to control for firm and time effects is a likely reason for the stronger financial effects in our study.

Internal Finance and the Aggregate Business Cycle

From data covering a substantial fraction of manufacturing inventories, our results show that inventory movements are linked to fluctuations in internal finance. Three facts stand out: the economically important cash flow coefficients for large as well as small firms, the dominant share of cash flow as a source of funds, and the dramatic procyclical movements of cash flow. Collectively, these facts help explain why aggregate inventory investment is so volatile over the business cycle. In this section, we explore the macroeconomic significance of our results by examining the extent to which our point estimates, together with cyclical fluctuations in internal finance, can explain aggregate inventory movements. We also consider how the presence of financing constraints contributes to the differences in the size of inventory investment shortfalls, along with other components of investment, from recession to recession.

Internal Finance and Aggregate Inventory Investment

There are several explanations for the volatility of inventory investment, including accelerator effects and cost or technological shocks. We do not argue that these factors are unimportant. (Indeed, our results support the significance of sales.) Rather, we have tested whether a "new view" about overall investment instability is also important for inventory investment, after controlling for other effects. Broadly stated, this new view is that financing constraints help to propagate the business cycle. While not truly "new"—having been articulated in some form by a variety of authors for decades—this view has been revitalized in mainstream macroeconomics by an outpouring of empirical and theoretical research.[67] Our work is part of this new literature, focusing on fluctua-

67. Finance is central to Keynes's investment theory. Financial effects on investment also figure prominently in the research of Gurley and Shaw (1955), Davidson (1972), and Minsky (1975). The surveys by Bernanke (1993) and Gertler (1988) cover much of the recent work.

tions of internal finance as the key financial variable driving inventory investment.

We are therefore led to the question of how much aggregate cyclical volatility of inventory investment can be explained by internal finance. Clearly, the answer depends on the time period one examines, and our regression results cover only the past two recessions. Also, one must use caution in extending our results based on Compustat manufacturing firms to the economy as a whole. Nevertheless, we present some suggestive computations to illustrate the possible importance of internal finance for aggregate inventory investment.

From the *QFR* data for manufacturing firms, the shortfall in cash flow for manufacturing firms, relative to trend, was $44 billion for the early 1980s recession (in 1987 dollars); the shortfall in inventory investment was $26.9 billion.[68] Assume that small firms account for 35 percent of aggregate inventories.[69] Multiplying the sum of the cash flow coefficients from period 1 in table 4 for small firms (0.428) by 35 percent of the cash flow shortfall yields an inventory investment shortfall of $6.6 billion for the early 1980s recession, or about 25 percent of the actual shortfall. A similar calculation for large firms, with the sum of their cash flow coefficients over the same period (0.227) multiplied by 65 percent of the cash flow shortfall, explains 24 percent of the aggregate inventory shortfall. If one attributes these cash flow effects for both small and large firms completely to financing constraints, the internal finance shortfall can explain nearly half of the inventory investment shortfall during the early 1980s contraction.[70]

68. The geometric cash flow trend is estimated from a regression over the period that begins at the cyclical peak in 1978:4 and ends at the peak in 1989:1. The use of a peak-to-peak sample avoids biasing the trend by including partial cycles. Trend growth in real manufacturing cash flow for this period is 2.0 percent a year. Because real inventory investment for *QFR* manufacturing firms was trendless over this period, the inventory investment shortfalls are measured relative to the sample average.

69. Gertler and Gilchrist (1994) report that firms with nominal assets less than $250 million accounted for 32 percent of manufacturing sales in 1990. Since our cutoff is $300 million in 1987 dollars, and because the inventory-to-sales ratio is higher for small firms than for large firms, we use a 35 percent weight for small firms.

70. This result can be bracketed with our estimates from other regressions. The smaller cash flow coefficients from table 5 give a more modest, but still substantial, result (25 percent of the inventory shortfall for small and large firms together), while the larger instrumental variables coefficients (table 6) can explain over 80 percent of the inventory shortfall.

For the early 1990s recession, the results are somewhat different. The cash flow coefficients in table 4 are smaller in this period. There was, however, a very large shortfall of nearly $90 billion in manufacturing cash flow, relative to trend. Using the coefficient estimates from table 4 (period 3), the internal-finance shortfall for small firms again explains about 25 percent of the inventory investment shortfall, but finance effects for large firms account for only 3 percent.

Our rough calculations suggest that financing constraints on small firms alone could account for about a quarter of the shortfall in aggregate manufacturing inventory investment in both the early 1980s and early 1990s. To the extent that large firms also face such constraints, as reflected by the positive cash flow coefficients in their inventory investment regression for the early 1980s, the cash flow shortfall for large firms also explains a large part of the reduction in inventory investment during this period. But the large-firm effect almost disappears in the early 1990s downturn. We now offer an explanation for this finding.

Composition of Investment Shortfalls during Recessions

A complete theory of cyclical inventory investment should explain not only cyclical volatility but also why inventory behavior differs across cycles. In our context, the question is the *composition* of shortfalls in total investment for a given reduction of internal finance. That is, how much of a cash flow shortfall will be reflected in reduced inventory investment as opposed to other firm activities, such as fixed investment?

In his classic work on business cycles, Moses Abramovitz reports evidence relevant to this issue.[71] He finds an inverse relation between the length of cyclical phases and the change in inventory investment. For phases that last less than a year, inventory investment accounts for 96 percent of the change in output. For phases of moderate duration (1.5 to 2.25 years), 47 percent of the change in output comes from inventory investment. For the two long phases Abramovitz studied (each exceeded 3.75 years), changes of inventory investment amount to only 19 percent of the change in output. Blinder and Maccini report statistics with similar implications for postwar recessions. For the two most severe recessions covered by their statistics (1974–75 and 1981–82), de-

71. Abramovitz (1950).

clines in inventory investment averaged 53 percent of the drop in output; while in the other recessions, they averaged 98 percent of the output drop. Zarnowitz reviews the historical record and confirms these facts: "[i]nventory investment plays a very important role in short and mild cycles, whereas fluctuations in fixed investment acquire a greater weight in the longer and larger cycles."[72]

The experience in the two most recent recessions provides additional information on the composition issue. Robert Hall shows that the shortfall in fixed investment is about three times as large as the shortfall in inventory investment, measured as deviations from trend over 1989–91.[73] A similar calculation for 1981–83 gives a shortfall in fixed investment that is only 36 percent larger than the shortfall in inventory investment.

The link between internal finance and inventory investment helps explain these observations. We have argued that the amount by which firms cut inventory investment, compared with fixed investment, when internal finance declines will depend on the relative marginal costs of reducing each component. In short recessions, the low adjustment and liquidation costs of inventories induce firms to offset much of their shortfall in cash flow with lower, even negative, inventory investment. As inventories are depleted during a protracted recession, however, the opportunity cost of further liquidation rises as the marginal product of inventories rises. Similarly, if firms enter a recession with unusually low inventory stocks, they will find it more costly to deplete inventories. In either of these cases, fixed investment will likely bear a larger burden of the shortfall in cash flow.[74] In earlier work, we analyzed this kind of connection between fixed and working-capital investment (much of which is inventories) and found that working-capital investment is very sensitive to cash flow. Furthermore, the evidence indicates that firms use declines in working-capital investment to "smooth" fixed investment relative to negative cash flow shocks.[75]

This perspective helps explain differences in the composition of aggregate-investment reductions between the past two recessions. The

72. Blinder and Maccini (1991a) and Zarnowitz (1992, p. 27).

73. Hall (1993, figure 3).

74. This argument relates to research emphasizing the strength of firms' balance sheets as a determinant of investment. See Bernanke and Gertler (1989), Calomiris and Hubbard (1990), and Hubbard and Kashyap (1992).

75. See Fazzari and Petersen (1993) and Carpenter (1992).

manufacturing and trade inventory–to-sales ratio fell during most of the 1980s.[76] This phenomenon could be due to changes in inventory management procedures—adoption of the much publicized "just-in-time" approach, for example. Under these circumstances, firms would have had less flexibility to liquidate inventory stocks when cash flow weakened in the late 1980s and into the 1990s. This interpretation is consistent with our regression results: the cash flow coefficients decline substantially for both small and large firms between our first and third periods.

Our view of the linkage between internal finance and the multiple components of investment is different from conventional analyses of inventories that treat inventory changes as an isolated phenomenon. Many authors have concluded that macroeconomic fluctuations would be substantially less severe, indeed some cycles may cease to exist, if inventories were more stable. For example, Rudiger Dornbusch and Stanley Fischer write,

> If inventories could be kept more closely in line with sales, or aggregate demand, fluctuations in inventory investment and in GNP would be reduced. As business methods are improving all the time, the hope is often expressed that new methods of management will enable firms to keep tighter control over their inventories and thus the prospects for steadier growth can be improved.[77]

If internal-finance flows are an important determinant of inventory fluctuations, however, this conventional view is incomplete. Firms that do not respond to reduced cash flow by cutting inventory investment must still satisfy financing constraints. Cash flow shocks will then have a larger impact on other firm activities, such as fixed investment, employment, and R&D.[78] Therefore, highly procyclical inventory fluctuations might be viewed in part as symptoms of the deeper problem created by financing constraints. Unless the underlying fluctuations of internal finance are dampened, reduced inventory volatility might not contribute as much to macroeconomic stability as it might appear.

76. See, for example, Morgan (1991).

77. Dornbusch and Fischer (1990, p. 307).

78. Aggregate data presented by Kopcke (1993, figure 4) support the idea that fixed investment and inventories compete with each other for cash flow. He finds that fixed investment nearly equals cash flow over a long horizon, which is not surprising since inventory investment is a small use of funds in the long term. But fixed investment rises about 30 percent above cash flow in both the 1981–82 and 1990–91 recessions, just at the time of negative inventory investment.

Conclusion

A well-known but underemphasized feature of the business cycle is that the flow of internal finance is very procyclical. It is also well known that internal finance is the predominant source of funds for most firms in the U.S. economy. Recent research indicates that access to internal finance constrains firms' investment expenditures, suggesting that the dramatic fluctuations in internal finance in the U.S. economy may be important for explaining the pronounced cyclical movements in aggregate investment.

Internal finance is used to fund many different investment activities, including fixed investment and R&D. However, we argue that because of relatively low adjustment costs, inventories often bear a disproportionate share of internal-finance fluctuations. Inventories are a large proportion of firms' assets and are readily reversible. For example, firms can obtain liquidity by reducing the rate at which they replenish the stock of raw materials. Because the stock of inventories is so large relative to quarterly cash flow for the typical firm in our study, a comparatively small percentage decline in the stock of inventories would be sufficient to offset even the large percentage reductions in cash flow that occur in recessions.

To test the linkage between internal finance and inventories, we use quarterly panel data for manufacturing firms, which cover a large fraction of aggregate inventories. To our knowledge, this study is the first to test for the importance of financing constraints with high-frequency panel data. There are several methodological advantages to this approach, including the ability to employ highly disaggregated industry time dummies to control for alternative explanations of inventory volatility, such as technological shocks and interest rates. In addition, our study may be the first to examine *individual* recessions using panel techniques, which can be done only with high-frequency data.

Our results strongly support the view that firms absorb shocks to internal finance through changes in inventory investment. The findings from three separate panels indicate that internal finance has a stronger effect on inventory investment for small firms than for large firms. The effect is economically important, however, even for large firms in two of our three panels. That cash flow affects large firms' inventory investment helps establish the importance of internal-finance fluctuations to aggregate movements in inventory investment.

Inventory fluctuations often account for a majority of the decline in output during recessions, and our results help explain this phenomenon. We argue, however, that the dampening of inventory movements will not necessarily reduce cyclical fluctuations in the aggregate economy. Fluctuations in internal finance must be absorbed somewhere, and in many recessions, inventory disinvestment is the method firms choose. However, if inventory stocks are low going into a recession, or if they are drawn down during a prolonged recession, financing constraints should have a greater impact on other firm activities, particularly fixed investment. This observation helps to explain major differences in the composition of investment shortfalls in previous business cycles.

APPENDIX

Characteristics of Data

COMPUSTAT contains data compiled in a fiscal year format. Compustat aligns the fiscal quarters in the data with calendar quarters as follows. If the company's fiscal quarter ends in the same month as a calendar quarter, the adjustment is straightforward. In cases where the end of a firm's fiscal quarter does not coincide with the end of a calendar quarter, we adjust the data so that the majority of the fiscal quarter is assigned to the appropriate calendar quarter.

Cash flow is defined as income before extraordinary items plus the sum of noncash charges against income. The bulk of these charges consist of depreciation and amortization expenses. The remaining charges are extraordinary items and discontinued operations, equity in net loss, and deferred taxes. The sales variable reported by Compustat is net of cash and trade discounts and other allowances for which customers receive credit. To construct a real measure for sales, we divide sales by the implicit GNP price deflator. We use the implicit price deflator for nonresidential investment to construct all other real variables.

A clear explanation of the standard accounting treatment of inventories and current income can be found in a book by Ray Garrison.[79] He

79. Garrison (1982).

notes that product costs go into the manufacture of goods and consist of materials and direct labor costs. He then states that

> Product costs are often called *inventoriable* costs. The reason is that partially completed units or unsold units go into inventory, and the costs involved in their manufacture follow them into the inventory accounts. Thus, such costs are said to be *inventoriable* costs. The concept of an inventoriable or product cost is a key concept in managerial accounting, since these costs can end up on the balance sheet *as assets* (either as work in process or as finished goods) if manufactured products are only partially completed or are unsold at the end of a period.[80]

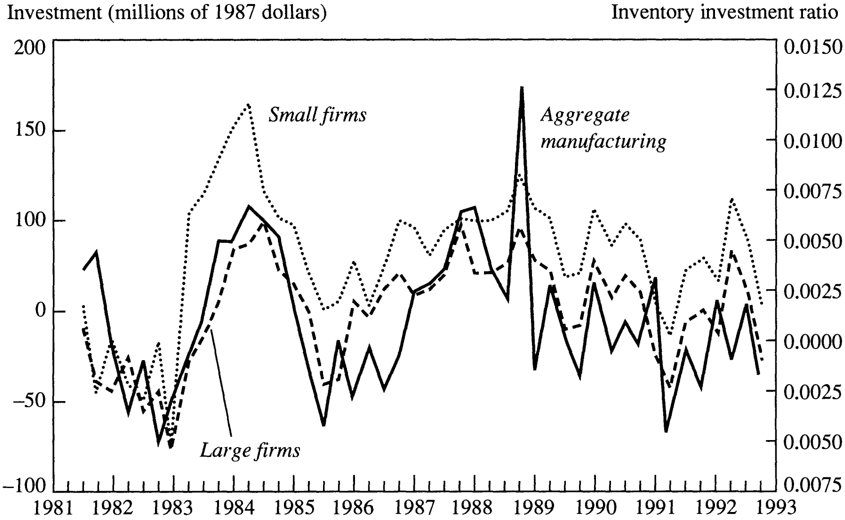
Therefore, firms do not affect their income or cash flow simply as the result of inventory investment. The costs of producing goods put into inventory are not reflected in income until the goods are sold.

Compustat reports book values for inventories as well as the method that a company uses to value its inventory. Firms may use more than one method to evaluate their inventories. If so, Compustat indicates the predominant method. We adjust both the lagged stock of inventories and the inventory investment variable in our regressions to minimize the bias introduced by historical cost accounting. The value of the stock of a firm's inventory will be understated in an inflationary environment when inventories are evaluated with LIFO methods. To adjust, we group firms into LIFO and non-LIFO categories. For LIFO firms, we apply an algorithm developed by Michael Salinger and Lawrence Summers to estimate a replacement value for the inventory stock.[81] For FIFO firms, the change in inventories will be overstated if there is a positive inflation rate, because the end-of-period value will include the nominal inflation of the stocks. To remove the inflation bias from FIFO firms' inventory investment variable, we compute the change in inventories after deflating the stocks. For LIFO firms, we construct the flow measure of inventory investment by differencing the stock and then deflating.

The seasonal adjustment procedure described in the text generates an inventory investment series that closely resembles the seasonally adjusted change in nonfarm business manufacturing inventories compiled by the Census Bureau. Figure A1 shows the close correspondence between the aggregate manufacturing inventory investment series and the means of our inventory investment data, seasonally adjusted with four-

80. Garrison (1982, p. 34).
81. Salinger and Summers (1983).

Figure A1. Inventory Investment[a]



Source: Authors' calculations using Compustat data.

a. Aggregate manufacturing inventory investment (left scale) is shown in millions of 1987 dollars. Micro inventory investment data (right scale) are divided by beginning-of-period total assets and are seasonally adjusted with quarterly dummy variables.

digit SIC quarter dummies. Our data capture very well the major movements in aggregate inventory investment during the sample period. In addition, an examination of the partial autocorrelation function of our series, after accounting for seasonal fluctuations with dummy variables, indicates that no partial autocorrelation function is significant at seasonal frequencies.

Comments and Discussion

Anil K. Kashyap: This paper nicely marries Robert Carpenter's dissertation work on inventories and Steven Fazzari and Bruce Petersen's research on internal finance. The resulting product is an interesting blend of careful work on an important topic. Indeed, I think the results are sufficiently convincing that rather than quibbling with details of the empirical work, I will spend most of my time discussing an alternative interpretation of their results.

Let me start by reviewing what I see as the three main findings of the paper:

—During the early and late 1980s, small firms' inventory investment was more sensitive to internal funds than was the inventory investment of large firms. (The large-firm cash flow effects are only significant in one of the four cases shown tables 4 and 5.)

—During the mid-1980s, there was no important difference between the small and large firms' inventory sensitivity to cash flow—see the middle panels of tables 4 and 5.

—These findings are very robust to alternative specifications, and in particular there is little evidence to suggest that interest rate–cost of capital considerations have much to do with inventory fluctuations.

In fact, Owen Lamont, Jeremy Stein, and I, as well as others, have found these same sorts of results using lower-frequency data and fewer econometric controls.[1] It is reassuring to see that the stylized facts really do not collapse following careful econometric work.

Carpenter, Fazzari, and Petersen read this evidence as saying that, as a typical recession unfolds, internal finance falls, and as a result of capi-

1. For example, see Kashyap, Lamont, and Stein (1994).

tal market imperfections that limit firms' ability to borrow, firms are forced to cut spending. These cuts show up in inventories because inventories are easily adjusted and the cuts serve to exacerbate the downturn—a mechanism sometimes described as the financial accelerator.[2]

While I mostly agree with their characterization, I would change the emphasis of the story. My main concern is that I think the authors understate the connection between this work and the monetary policy transmission mechanism. To see the connection to the monetary transmission mechanism one must first buy the assumption that the main macroeconomic difference between the three periods that they study is the stance of monetary policy: each of their episodes includes a slowdown in income followed by a recovery and an accompanying inventory cycle. Most observers would agree that credit conditions were tighter in the first and third periods than in the middle period. In fact, I suspect all regular Brookings panel participants would agree that the Federal Reserve probably would have triggered a recession by gently raising rates in 1985 and 1986 (rather than lowering them).

Reinterpreting their results in light of this characterization of the three episodes suggests the small firm–large firm differentials are much more pronounced during the tight money episodes. Why is this conclusion noteworthy? The standard approach of the papers that were spawned by Fazzari, R. Glenn Hubbard, and Petersen's 1988 paper is to take coefficients for large firms as a benchmark that controls for possible econometric misspecification and to read the differences between coefficients for the large and small firms as a measure of the importance of capital market imperfections.[3] Using this logic suggests that these imperfections are primarily important during periods of tight monetary policy. More specifically, the present authors can be interpreted as having demonstrated that because of capital market imperfections, monetary policy operates partially by affecting inventory investment.

This alternative interpretation has a number of interesting implications. First, it helps resolve the following long-standing puzzle. As the authors mention, it is well-known that in postwar U.S. recessions, declines in inventory investment account for a large fraction of the total peak-to-trough movement in GNP.[4] It is also generally agreed that re-

2. See Bernanke, Gertler, and Gilchrist (forthcoming).
3. Fazzari, Hubbard, and Petersen (1988).
4. See Blinder and Maccini (1991) for more discussion.

cessions usually follow a period of tight monetary policy. Yet, the obvious connection that links the inventory decline to increased interest rates is very difficult to establish. As Alan Blinder and Louis Maccini put it in their recent survey, "little influence of real interest rates on inventory investment can be found empirically."[5] (Recall that Carpenter, Fazzari, and Petersen can find no evidence of inventory investment depending on interest rates. In fact most of their estimated interest rates effects have the wrong sign: higher rates lead to more inventory investment.)

The authors' evidence, therefore, suggests that it is inappropriate to dismiss the "financial" account of the cyclical behavior of inventories: instead of keying on how monetary policy might operate though interest rates, these results highlight the potency that might arise because it can significantly affect access to credit. Put differently, their evidence demonstrates the importance of thinking about the connection between monetary policy and firms' access to credit.

What are the links between monetary policy and credit availability? There are a couple of potential channels. One way that tight monetary policy could operate without relying on a strong cost-of-capital channel is for it to influence collateral values. For example, periods of high interest rates are times when the collateral value of future cash receipts falls. In a world of information and moral hazard problems, any drop in collateral values can decrease access to financing.

A slightly different mechanism emphasizes the importance of banks in the monetary policy transmission mechanism. Because the Federal Reserve raises interest rates by contracting bank reserves, a tightening of monetary policy (empirically) tends to lead to less lending by banks;[6] one of the margins on which banks can operate to offset the shock to reserves is to reduce lending. With less bank lending available, some firms may have to reduce inventory investment during a time of tight monetary policy.

Clearly, the collateral story and the lending story are closely related. Both attribute inventory movements in a downturn to a "cutoff" in the flow of credit, although in the latter case the cutoff represents an inward shift in the bank loan supply schedule, while in the former it does not.

5. Blinder and Maccini (1991a, p. 82).
6. Bernanke and Blinder (1992).

Similarly, both stories suggest that standard theoretical inventory models need to be expanded to include more than just interest rates to properly capture the role of financial factors. Nevertheless, I think that distinguishing between these two explanations for the cutoff in credit that may accompany a monetary tightening is important. The sorts of questions that hinge on separating the collateral and lending explanations include

—Will the ongoing transformation of the banking industry change the potency of monetary policy?

—Should the Federal Reserve be looking at some index of banks' lending positions to gauge the stance of monetary policy?

—Does the potency of monetary policy in different economies vary with the size or health of their banking systems?

While at this point it is too early to say whether either explanation is more important than the other, this topic is being actively studied, and I am optimistic that we will be able to say much more in another couple of years.[7]

Finally, I should mention that the analysis in the paper begins at the point where sales are already slowing down and cash flow is beginning to fall. This paper, therefore, is silent about the source of the initial impulse that leads to the slump that triggers the inventory runoff. Ideally, a complete theory would also explain how the shock originated. One intriguing possibility is that tight monetary policy, through its effect on access to credit, is the cause. In this case, the channel would have to operate through a reduction in access to funds to individuals and other final purchasers of inventories.

The idea that banks cut back on lending to individuals and other small customers before cutting off larger businesses is plausible. After all, smaller customers are likely to be more costly to service and generally will not have the kind of tight long-term relationship with a bank that a larger business would. There is also some indirect evidence suggesting that empirically bank lending to households gets squeezed more quickly during tight episodes than does lending to firms. For instance, Lawrence Christiano, Martin Eichenbaum, and Charles Evans show that noncor-

7. See Cecchetti (1994), Gertler and Gilchrist (1993, 1994), Hubbard (1994), and Kashyap and Stein (forthcoming).

porate bank lending falls more quickly following an increase in interest rates than does corporate borrowing.[8]

This conjecture about how monetary policy might cause the initial drop in internal funds has several testable implications. First, one should find that the response of bank lending to a change in monetary policy differs across the type of customers. As a practical matter, one would want to know whether lending to consumers drops quickly following a monetary tightening. Second, this conjecture has cross-sectional implications about the nature of the inventory runoff that follows a shift in monetary policy: firms whose customers depend on financing their purchases with bank loans should be the ones that are most likely to see a sales decline. I am unaware of any tests of these propositions, but checking them out seems like a next step in trying more completely to understand Carpenter, Fazzari, and Petersen's results.

In the meantime, I hope the results in this paper will at least lead people to reconsider the relevance of standard models of inventory investment: most graduate students are now introduced to inventories in the context of the debate over production smoothing.[9] Indeed, in the benchmark linear-quadratic model of production cost minimization, the role of financial factors is subsumed into a discount rate that is often not even estimated. Regardless of exactly how one interprets the evidence presented by the authors, their evidence should convince everyone that the role of financial factors in the determination of inventories is much too rich to summarize using a single interest rate.

Benjamin M. Friedman: One of the greatest disappointments in postwar empirical macroeconomics has been our poor success in explaining—and, correspondingly, our virtually complete failure in predicting—fluctuations in nonfinancial firms' accumulation of inventories. The ups and downs of inventory investment account, arithmetically, for a large share of what we conventionally call business cycles. To a great degree, economists' well-known difficulty in predicting recessions has stemmed from our inability to anticipate movements in inventory investment. All this has not been for lack of trying. Given the quantitative importance of inventory investment in the variance of the growth of aggregate demand, numerous economists, including some writing in the pages

8. Christiano, Eichenbaum, and Evans (forthcoming).
9. West (1986).

of the *BPEA*, have attempted to model this aspect of macroeconomic behavior. But the returns to doing so have mostly fallen short.

Many of the researchers engaged in this effort over the years have expressed an a priori belief that financial conditions—somehow and in some form—ought to matter for firms' inventory decisions. Efforts to establish empirical support for financial influences on inventory investment, however, have mostly been frustrated (and, presumably, frustrating as well). A large part of the reason, I suspect, lies in the conventional use of one or another market interest rate to gauge how what happens in the financial markets affects decisions by nonfinancial actors in the economy, firms included. That usage in turn is a reflection of the assumption of perfect capital markets, which was forcefully reintroduced into the investment literature by Dale Jorgenson and others some 30 years ago.[1] The assumption of perfect capital markets means (among other things) that any firm wishing to borrow at "the going interest rate" can do so. Moreover, given the Modigliani-Miller result on the irrelevance of debt-equity structure, a perfect capital market further implies that any firm wishing to borrow at the going interest rate can do so in unlimited amounts.[2] Firms, therefore, are presumed to be strictly price takers and quantity setters in the debt market, and "the going interest rate" is a sufficient statistic embodying all information from the financial markets that is relevant to their decisions.

By contrast, within the past 15 years or so, a new literature of financial markets—pioneered by Joseph Stiglitz and Andrew Weiss, Michael Jensen and William Meckling, Stewart Myers and Nicholas Majluf, and others—has established a solid theoretical basis for rejecting the notion that capital markets are perfect in this important sense.[3] Where previously a researcher seeking to incorporate ideas of credit rationing and financial quantity constraints into applied research had to face the challenge of "where is your optimizing model?," and the associated criticism of basing empirical work on "ad hoc" constructs, today it is researchers seeking to base models of investment expenditures on perfect capital markets who should appropriately explain their justification for assuming away the well-understood consequences of asymmetric information,

1. Jorgenson (1963).
2. Modigliani and Miller (1958).
3. Stiglitz and Weiss (1981), Jensen and Meckling (1976), and Myers and Majluf (1984).

moral hazard, adverse selection, and conflicts between principals and their agents. That conventional research practice in macroeconomics has thus far made only a limited shift in this direction mostly reflects the economics profession's usual bias toward the presumption of perfect markets.

Carpenter, Fazzari, and Petersen usefully seek to explore inventory investment on the assumption that most nonfinancial firms have limited access (or none at all) to external financing and, further, that even the first dollar of whatever external funds are available comes at a cost greater than the opportunity cost of internally generated funds. The relevant supply curve describing the individual firm's investment possibilities, which Jorgenson-type models take to be horizontal, is therefore not only not horizontal but discontinuous. Internal cash flow, which is the primary focus of the authors' empirical work in this paper, matters because it determines the location (the horizontal coordinate) of that discontinuity in the supply curve. The empirical results presented in the paper, based on panel data that are not only highly disaggregated but also fairly comprehensive as these things go, provide strong support for the claim that the location of this discontinuity in the supply of finance is in turn an important factor in inventory decisions for many firms, both large and small. The specific results are mostly robust, and the overall message is persuasive. Indeed, I would view the authors' finding that financing constraints were less relevant than usual during the subsample including the 1990–91 recession less as cause for doubt about the robustness of the underlying relationship than as further confirmation of the widespread view, also expressed recently in *BPEA*, that the 1990–91 recession was itself unusual in not having been proximately caused by tight monetary policy.[4]

Although the authors do not say so explicitly, the strength of their findings should also go a good way toward resolving the long-standing question of why "accelerator" models of investment tend to perform so well empirically. Most economists are aware that accelerator models—that is, models in which the key determinant of investment is the change in sales—lack the solid theoretical foundation that supports either the Jorgenson-style neoclassical model or models based on Tobin's q ratio. Yet accelerator models typically outperform either neoclassical models

4. Perry and Schultze (1993).

or "q" models in empirical comparisons. The results presented here suggest a plausible explanation: the change in sales, on which accelerator models focus, is often a good proxy for either profits or internal cash flow, and in a model with imperfect capital markets that financial flow *should*, on perfectly sound theoretical grounds, be a major determinant of investment. As the authors explain, there is good reason to believe that the relevance of the cash flow constraint is all the greater in the particular case of inventory investment.

My principal reservation about the authors' work here stems from the partial nature of their analysis, in the sense not only of partial versus general equilibrium but also of analysis of only one element in what is presumably a simultaneous set of decisions by the firm. In both senses, the problem comes down to a difficulty in specifying just what exogenous shock is under analysis.

For example, in table 7 the authors report that the change in cash and equivalents held by the firm affects inventory investment negatively. Negative variation between cash holdings and inventories makes perfect sense if both variables are responding to an exogenous shock in cash flow. When cash flow declines, drawing down cash holdings and cutting back on inventories are substitute ways of achieving the needed accommodation, and the more the firm draws down its cash holdings the more it can go ahead and invest in inventories. But these equations control for cash flow, and so the independent shock represented by the cash holdings variable is hard to specify. To take just one hypothetical example, if cash holdings go down because the firm has suffered a default in its liquid securities portfolio, the inventory response (if any) would presumably be to accumulate less, and so the sign of the effect would be *positive*. The ambiguity here simply reflects the use, as an independent regressor, of a variable on which the firm is deciding simultaneously with its inventory decisions. The same argument holds, with signs reversed, for the change in short-term debt. (One could even make the argument that inventory decisions and outcomes are *prior* to decisions on cash holdings and short-term debt outstanding.) The authors' use of instruments for these variables clearly indicates their awareness of this matter, but that does not make it go away. What is needed is a fuller treatment encompassing inventory and portfolio decisions together.

The limitation in the authors' analysis due to its partial equilibrium nature is similar. By far the most dramatic claim made in the paper is the rejection of the familiar notion that "macroeconomic fluctuations would be substantially less severe . . . if inventories were more stable." The authors' argument here takes a negative shock to the aggregate cash flow of all firms as given, and assumes that firms that do not accommodate this shock by cutting back on inventory accumulation will therefore cut back on "other firm activities, such as fixed investment, employment, and R&D." But if on average firms have not cut back on their buying from one another, where has the negative shock to *aggregate* cash flow come from in the first place? (Recall how smooth consumption spending typically is over the business cycle.) And even if the aggregate of firms does somehow experience a negative cash flow shock, why can it not achieve the needed accommodation by drawing down cash holdings? Or by taking on more debt? The answer to this latter question, of course, is that many firms have little or no cash holdings to draw down, and in a world of imperfect capital markets they also have little or no access to external finance. This, after all, is the authors' fundamental point. But establishing its relevance and implications in a business cycle context again requires a fuller model, capable not only of clearly specifying the shocks under study but also incorporating firms' actions in both financial and nonfinancial markets.

In their paper the authors have usefully pushed us along this path by providing strong—to me, persuasive—evidence of the effect of financing constraints on a key element of economic behavior at the individual firm level: finance *is* an important determinant of inventory investment. That there is much work yet to be done in establishing the macroeconomic implications of this relationship in no way diminishes the usefulness of the evidence demonstrating it.

General Discussion

Gregory Mankiw raised the possibility that the estimated effect of cash flow on inventories does not reflect financing constraints but arises because cash flow is correlated with expectations of future profitability, which affects desired stocks. Steven Fazzari responded that such an omitted-variable bias was unlikely to be important because inventories represent short-term investments with low adjustment costs, so that expectations of future profitability should not matter much. He noted that such expectations should be more important in explaining fixed investment than in explaining inventories. However, the estimated effects of cash flow turn out to be larger in explaining inventories than in explaining fixed investment, suggesting that expectations of future profitability are not driving the estimates.

Charles Schultze questioned whether adjusting inventories is less costly than adjusting fixed capital since adjusting finished-goods inventories requires changing employment, which may be more costly than simply delaying investment projects. Fazzari agreed that adjustment costs could be high for finished-goods inventories, but not for materials inventories, which firms can simply draw down in the course of production. In aggregate data—and probably in their data—materials inventories account for a large portion of the variance in total inventories. Unfortunately, the data in the paper do not allow disaggregation by type of inventory.

Fazzari also noted that if cash flow were just signalling future profitability, it should be significant across all firm types and periods. However, cash flow is insignificant for large firms in the last sample period. Robert Carpenter added that, when the sample is split into three size classes, the cash flow coefficients for the largest and smallest firms are significantly different in all three periods. Mankiw responded that the omitted-variable bias might simply be greater in the case of small firms; because they face more uncertainty about future prospects, the correlation between current cash flow and future profitability should be larger for them than for large firms. To test the omitted-variable hypothesis against the credit constraint hypothesis, Robert Hall suggested focusing on cash flow windfalls, since they would ease financing constraints but would be unrelated to future profitability.

Some panelists suggested that alternative sample splits might be informative. Glenn Hubbard noted that the key is to identify firms with a high shadow value of internal funds, suggesting splits based on whether firms pay dividends or whether they have access to the commercial-paper market. These splits are unlikely to be affected by uncertainty about the future. Kevin Hassett suggested a split between types of small firms: "buggy whip" companies whose markets are small and stable and "biotech" companies that are small but have the potential to grow rapidly. For buggy whip firms, cash flow probably is not highly correlated with future sales growth, since these firms are unlikely to grow much.

Therefore, if cash flow affects inventories for these firms, financing constraints are the likely channel. By contrast, cash flow for the "biotech" firms is likely to be highly correlated with future profitability. As a possible way to identify these firms, Hassett suggested splitting the small-firm sample by industry or age of company. Stephen Oliner noted that if financing constraints are the reason for the effects of cash flow, the coefficients on cash flow should be larger in periods of tight financial conditions than in periods of easy money. With such a split in mind, he found it puzzling that the coefficients on cash flow are larger for the mid-1980s than they are for the late 1980s and early 1990s when the tightness of credit was widely acknowledged.

Several panel members observed that firms can adjust to cash flow shocks along many margins other than inventory holdings. Hall noted that trade credit was an important source and use of funds and that firms can draw cash by "selling" market share. John Shoven asked why firms should absorb cash flow shocks in inventories rather than in cash stocks. Fazzari agreed that optimal portfolio adjustment should involve changes along many margins but emphasized that inventories should still be a key part of the adjustment.

Hall suggested testing this by using all the portfolio elements that are decision variables of the firm as dependent variables and using an exogenous cash or credit shock as the only explanatory variable.

Although monetary policy is often seen as the source of cash flow shocks, Benjamin Friedman noted that the precise link between monetary policy and such shocks still needs to be isolated. He suggested that the link might be through higher interest payments and self-fulfilling fears of reduced profitability. Fazzari suggested that consumption shocks were probably a prime source of cash flow disturbances. Although consumption is relatively smooth, it is the largest component of aggregate demand, so even small variations can have large cash flow effects.

Anil Kashyap concluded that the importance of credit constraints on inventories has been demonstrated strongly enough; the teaching of inventory theory in graduate school, which tends to focus only on production smoothing, should be changed.

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