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Has Inventory Investment Been Liquidity-Constrained? Evidence from U.S. Panel Data

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Abstract

Based on an analysis of quarterly panel data for U.S. firms, this paper finds that inventory investment has been liquidity-constrained in most periods during 1975–97, but less so, or not at all, during recessions. This result holds irrespective of whether the firm has a bond rating, contrary to the finding of Kashyap, Lamont, and Stein (1994) that inventory investment is not liquidity-constrained, except during recessions and only for firms without bond ratings. Our result can be justified on the grounds that inventory fluctuations are largely attributable to unexpected sales shocks during recessions, and that firms increase liquid assets before recessions.

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Contents

I. Introduction

It is well known that inventory movements, closely related to output fluctuations, are a useful indicator of business activities. It is, therefore, interesting to investigate what factors determine inventory movements. While there is little evidence of a strong effect of real interest rates on inventory demand (Blinder and Maccini, 1991), recent studies, including those by Kashyap, Lamont, and Stein (1994, hereafter KLS) and Friedman and Kuttner (1993), suggest that inventory investment appears to be sensitive to liquidity or monetary shocks. In particular, KLS find that, based on an analysis of annual micro data, inventory investment is liquidity-constrained during recessions only for firms without bond ratings, whereas such a liquidity constraint is largely absent during nonrecessionary periods.

Friedman and Kuttner (1993) and Christiano, Eichenbaum, and Evans (1996) find that upon tighter monetary policy shocks, firms initially raise net funds or liquid assets. Consistent with this finding, Choi and Kim (2000) find a positive initial impact of tighter monetary policy on the liquid asset holdings of S&P 500 firms. They suggest that firms with access to committed bank credit lines make greater use of these lines in the face of tighter policy because the loan rate adjusts slowly and is expected to rise, given that policy shocks are persistent over time. These studies suggest that firms tend to conserve cash before the economy goes into a recession, a period typically preceded by tighter policy. If firms increase their cash reserves before a recession, inventory investment will not be constrained by liquidity at the onset of the recession. Moreover, negative sales shocks at the onset of the recession may lead to unplanned inventory buildups. However, inventory investment may decrease with lower expected sales as the recession deepens. The question then is whether the liquidity accumulated prior to the recession tempers such a decrease in inventory investment. Furthermore, why is inventory investment not liquidity-constrained during nonrecessionary periods when firms need more cash to finance their expansionary expenditures? In this paper, we attempt to address theses questions by examining whether and how inventory investment has been liquidity-constrained.

To test the hypothesis that a certain firm activity is liquidity-constrained, earlier studies tested the significance of the effect of a liquidity measure on the variable in question in reduced form regressions (Fazzari, Hubbard, and Petersen, 1988; KLS, 1994; Carpenter, Fazzari, and Petersen, 1994).[2] We also adopt the same approach to examine whether inventory investment is liquidity-constrained by regressing inventory investment on a liquidity measure and other control variables. Following KLS, we use a liquidity measure, defined as the beginning-of-period ratio of liquid assets (cash plus short-term investment) to total assets, focusing on the asset management side rather than on the cash flow side. While KLS estimate cross-section regressions for specific recession years or regressions using the 1974–89 annual data of U.S. firms, we estimate panel regressions using the 1975–97 quarterly data of U.S. firms.

[2] Many other studies estimate formally specified models of investment using the Euler-condition approach, which separates samples into constrained and unconstrained groups by financial criteria and then examine how the investment behavior of a group differs from that of the other group (e.g., Whited, 1992).

Contrary to KLS's finding, we find that inventory investment has been liquidity-constrained in most periods during 1975–97, but less so, or not at all, during recessions. This contrast is not driven by the difference in data frequency or sample period, though our datasets are different from KLS's. Our findings can be justified on the grounds that inventory fluctuations are largely attributable to unexpected sales shocks, and that firms increase liquid assets before recessions.

Our other findings are as follows. First, inventories are positively correlated with sales in levels, consistent with a Lovell (1961)-type target adjustment model. Second, inventory investment decreases with positive production cost shocks or higher interest costs, consistent with production-cost smoothing models (e.g., Blinder, 1986), but it increases with markups, consistent with Bils and Kahn's (2000) argument for countercyclical markups. Third, tighter monetary policy has greater adverse effects on inventory investment for non-S&P firms than it has for S&P firms after a few quarters, which implies that smaller firms, usually conserving a higher liquid assets–total assets ratio, reduce liquid assets more quickly after tighter policy. This finding corroborates the findings of Friedman and Kuttner (1993) and Bernanke, Gertler, and Gilchrist (1996) from flow of funds data and the finding of Gertler and Gilchrist (1994) from the Quarterly Financial Report. Since the sensitivity of inventory investment to liquidity is similar for big and smaller firms, the differential impact of tighter policy seems to reflect a difference in the policy's effect on liquidity adjustments.

Finally, our results suggest that for the period 1985–97 the sensitivity of inventory investment to liquidity does not depend on bond ratings. However, when cash flow is used in place of liquid assets, we find that inventory investment is less sensitive to cash flow when firms have bond ratings. It implies that firms with access to financial markets or committed loans can better protect their liquid assets from cash flow shocks, particularly through financing activities (e.g., debt issuance), than other firms can. Inventory investment, therefore, can be less sensitive to cash flow when firms have bond ratings, whereas the sensitivity of inventory investment to liquid assets remains about the same, regardless of bond ratings.

The paper proceeds as follows. Section II briefly reviews the related studies on inventory behavior and presents a theoretical background for the determinants of inventory investment. Section III describes the empirical specification of our model, and Section IV briefly describes the data. Section V presents the results of our inventory investment regressions along with robustness checks. Section VI concludes.

II. Inventory Behavior: Theoretical Background

A. Related Studies on Inventory Behavior

Evidence from recent inventory studies suggests the following stylized facts about inventory movements: (i) inventories are proportional to sales at low frequency (or in the long run)

(Eichenbaum, 1989; Gertler and Gilchrist, 1994);[3] (ii) there is a short run trade-off between inventory investment and sales (Hornstein, 1998);[4] and (iii) deviations from the target inventory-sales ratio are persistent over time (Bils and Kahn, 2000).

Facts (i) and (ii) reflect the fact that firms accumulate inventories in order to smooth production when faced with shocks to market demand or sales. Conventional models of inventories, such as target adjustment models and production smoothing models, capture these patterns. Considering that firms try to avoid running out of stock to protect their sales (a stockout-avoidance motive), target adjustment models (Lovell, 1961; Blanchard, 1983) posit that inventories are proportional to expected sales since adjustment costs arise when inventories deviate from some fixed proportion of sales. Also, production smoothing models (see, for listing of related studies, Blinder and Maccini, 1991) suggest that the desire to smooth production relative to demand makes inventories respond negatively to fluctuations of market demand in the short run. On the other hand, production-cost smoothing models (e.g., Blinder, 1986; Eichenbaum, 1989; West, 1990; Maccini and Rossana, 1991; Pindyck, 1994; Durlauf and Maccini, 1995) suggest that cost factors affect inventory investment. For example, observed cost shocks (Durlauf and Maccini, 1995) or unobserved technology shocks (Eichenbaum, 1989) contribute to explaining inventory movements.

Explaining fact (iii) requires exploring the determinants of the short-run dynamics of inventories, such as financial factors (KLS; Carpenter, Fazzari, and Petersen, 1994). Substitutability of inventories with liquidity as internal sources of finance (Carpenter, Fazzari, and Petersen, 1994; Choi and Kim, 2000) can also help understand the short-run dynamics of inventories. This is also consistent with Friedman and Kuttner's (1993) finding that liquid assets respond negatively to a positive shock in inventories. Nonfinancial factors can also cause persistent and systematic movements in the sales-inventory ratio. Bils and Kahn (2000) suggest that the inventory-sales ratio is positively correlated with markups, which decrease as the shadow cost of inputs rises with higher capacity utilization during booms.

B. A Conceptual Framework for Inventory Behavior

We consider the following motives for inventory demand. Inventories positively affect (i) sales by helping firms avoid stockouts (Bils and Kahn, 2000); (ii) production as a factor in production, comprising intermediate goods and raw materials as well as finished goods

[3] On the other hand, the observation that the variability of output exceeds that of sales (Blinder and Maccini, 1991) seems to go against a production smoothing model. Kahn (1992) argues that the observation can be explained by the stockout-avoidance model, while Blinder (1986) shows that the production smoothing model can be amended to be consistent with it. On the other hand, Krane and Braun (1991) show, using disaggregated physical-output data, that production is smoother than sales in about two-thirds of the 38 industries considered.

[4] Blinder and Maccini (1991) argue that sales and inventory investment normally are not negatively correlated. This argument plausibly reflects the mix of facts (i) and (ii). Indeed, Hornstein (1998) finds that inventory investment is positively correlated with sales over the business cycles but tends to be unrelated or negatively correlated with sales for short-term fluctuations.

(Kydland and Prescott, 1982; Christiano, 1988; Ramey, 1989); and (iii) business operations as buffers for internal finance (Carpenter, Fazzari, and Petersen, 1994).

We assume that a representative firm chooses inputs, including inventories, at the beginning of each period and then produces output before shocks to sales are realized. At the beginning of the period, the firm decides the *outright* inventory investment, Z_t, which, in the form of intermediate goods and raw materials, promotes production. The firm produces output, Y_t, as finished goods. Here, the sum of Z and Y corresponds to the conventional notion of output.

The beginning-of-period inventory, $\hat{V}_t$, is the sum of the inventory carried forward from the previous period, V_{t-1}, and the outright inventory investment, Z_t.

(1) $$\hat{V}_t = V_{t-1} + Z_t .$$

The end-of-period inventory, V_t, equals the stock of goods available for sale, $V_{t-1} + Z_t + Y_t$, minus sales, S_t.

(2) $$V_t = V_{t-1} + Z_t + Y_t - S_t .$$

We assume that shocks to sales occur at the end of each period, which makes actual sales different from expected sales:

(3) $$S_t = S_t^e + \varepsilon_t ,$$

where $S_t^e = E(S_t \mid \mathbf{I}_t)$ and E is the expectation operator conditioned on the information set $\mathbf{I}_t$, which contains all past and current variables except current sales. Substituting (3) into (2), actual inventory is given by

(4) $$V_t = V_{t-1} + Z_t + (Y_t - S_t^e) - \varepsilon_t .$$

Planned inventory investment then consists of the outright investment (Z_t) and the indirect investment through excess production ($Y_t - S_t^e$). Note that planned inventory investment differs from actual inventory investment by the amount of sales shock.

If the outright inventory investment is strictly constrained by real money holdings, m, then $\hat{V}_t \leq V_{t-1} + \chi m_t$, where $\chi \in (0,1]$ reflects the fraction of liquidity that can be used to finance outright inventory investment. This specification, however, is too restrictive. For a more flexible approach to capture that the liquidity constraint is binding to some extent, we use the "liquidity in production function" approach,[5] where liquidity enters into the production function as a production factor. In this case, output is a function of capital K_t, labor N_t, beginning-of-period inventory $\hat{V}_t$, and the resource available for inventory $V_{t-1} + \chi m_t$.

$$(5) \qquad Y_t = f(K_t, N_t, \hat{V}_t, V_{t-1} + \chi m_t).$$

A representative firm maximizes the expected discounted real cash flows subject to the sales equation, production technology, equations (1)–(3), and a balance sheet identity, as described in Appendix A. The optimization conditions motivate the equation for the beginning-of-period inventory as follows:

$$(6) \qquad \hat{V}_t = \Psi(\overset{(+)}{S_t^e}, \overset{(+)}{V_{t-1} + \chi m_t}; X_t),$$

where X_t is a vector that reflects cost factors and a productivity shock. Optimality also implies that indirect inventory investment through production can be expressed as

$$(7) \qquad Y_t - S_t^e = \Theta(\overset{(+)}{S_t^e}, \overset{(+)}{V_{t-1} + \chi m_t}; X_t),$$

where output is assumed to respond to expected sales more than proportionately (see equation A10 in Appendix A). Substituting equations (1), (6), and (7) into equation (4), actual inventory can be expressed as

$$(8) \qquad V_t = \Phi(\overset{(+)}{S_t^e}, \overset{(-)}{\varepsilon_t}, \overset{(+)}{V_{t-1} + \chi m_t}; X_t).$$

The inventory stock increases with expected sales, decreases with unexpected sales (ε_t), and increases with the liquid asset holdings, given V_{t-1}. To account for short-term finance constraint on inventory investment, m_t will be the relevant variable since the argument $V_{t-1} + \chi m_t$ in equation (8) reflects the liquid resource that can be transformed into the inventory stock.[6]

So far we have considered only interior solutions for inventories. However, inventory investment will be bounded from below at a certain level when sales slide during recessions, because firms may not be able to sell their inventories for disinvestment (due to overflows in the

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[5] Feenstra (1986) illustrates that the use of money in a production function and the use of money in the utility function are equivalent and that the use of the cash-in-advance constraint is a special case of the use of money in the utility function. For simplicity, we assume that inputs other than inventories are credit goods.

[6] If other inputs are also liquidity-constrained, liquid assets can be included in the production function, which makes inventory demand dependent on liquid assets. This is because liquid asset holdings increase productivity, enabling firms to hold more inventories, reinforcing the direct effect of liquidity on inventory.

market). Then firms can have a corner solution for Z_t, for example, at zero, which renders liquidity inoperative in equation (5). At the same time, indirect inventory investment can be overwhelmed by a negative sales shock. The liquidity constraint on inventory investment during recessions, therefore, will often be absent or much weaker than nonrecessionary periods.

The model in Appendix A also explains corporate liquid asset demand. Upon tighter monetary policy, firms initially increase their liquid assets, using committed lines of liquidity from banks, because the loan rate adjusts slowly and is expected to rise, given that monetary policy shocks are persistent (see equation A12).

III. Empirical Model Specifications

Equation (8) implies a positive link between sales and inventories in levels, abstracting from roles of the liquidity constraint, sales shocks, and cost factors. Thus, consider first a relationship between inventories and sales,

$$\ln V_{j,t}^{p} = \alpha_t + \rho \ln S_{j,t}^{p} + e_{j,t}, \tag{9}$$

where $V_{j,t}^{p}$ and $S_{j,t}^{p}$ are the planned values of the real inventory stock and real sales in period t, respectively, and $e_{j,t}$ is an error term. The time-varying parameter, α_t, may reflect the progress in inventory management over time. Since the regression represents how firms set the target inventory, both the inventory stock and sales are in planned terms. If the inventory–sales ratio remains stable, as implied by target inventory models, then $\rho = 1$.

Next we specify a dynamic inventory adjustment, which incorporates not only a long-term relation implied by equation (9) but also the effects of short-term factors, such as demand and cost shocks and financial conditions, as implied by equation (8). Since equation (9) implies that firms adjust inventories to reduce the gap between the actual *V/S* ratio and a target ratio, the lagged *V/S* ratio is included as a regressor. To identify the liquidity effect on inventory investment without involving a simultaneity bias, we use the beginning-of-quarter (i.e., one-quarter-lagged) liquidity. Following KLS, we measure the firm's liquidity position by $\hat{m}_{j,t} / \hat{A}_{j,t}$, where $m_{j,t}$ and $A_{j,t}$ are liquid assets and total assets both in real terms, and ^ denotes the beginning-of-quarter value.

For firm j at time t,

$$\begin{aligned} \Delta \ln V_{j,t} &= b_1 \Delta \ln V_{j,t-1} + b_{vs} \ln(V_{j,t-1} / S_{j,t-1}) + \Sigma_{k=0}^{2} b_{sk} \Delta \ln(S_{j,t-k}) \\ &\quad + b_c \Delta \ln C_{j,t} + LIQ_{j,t} + Q\tau + \theta^{I} + \theta_{1,t}^{I} + \theta_{2,t}^{I} + \theta_{3,t}^{I} + w_{j,t}, \end{aligned} \tag{10}$$

where $V_{j,t}$, $S_{j,t}$, and $C_{j,t}$ are the real inventory stock, real sales, and real cost of goods in period t, and $LIQ_{j,t}$ represents the linear combination of the effect of liquidity constraints. Inventory investment is interpreted as liquidity-constrained when the liquidity coefficient is positive and statistically significant. When we allow for the year-by-year (quarter-by-quarter) effect of the liquidity constraints, we define $LIQ_{j,t} = \sum_{d=1}^{D} b_{md} (\hat{m}_{j,t} / \hat{A}_{j,t}) \cdot Ddum_t^d$, where $Ddum_t^d$ is a date dummy that takes the value one if t belongs to year (quarter) d and value zero otherwise. The $Q\tau$ term represents the linear combinations of the effect of other variables. The θ^I term is the linear combination of fixed-industry effects, and $\{\theta_{p,t}^I\}_{p=1}^3$ controls for seasonality in industry I (2-digit quarter dummies), and w_{jt} is the error term.

We also consider an alternative specification to equation (10), scaling inventory investment and changes in sales by the firm's beginning-of-quarter assets (as in Carpenter, Fazzari, and Petersen, 1994). For firm j at time t,

(10′)
$$\Delta V_{j,t}^N / \hat{A}_{j,t}^N = b_1(\Delta V_{j,t-1}^N / \hat{A}_{j,t-1}^N) + b_{vs}(V_{j,t-1}^N / S_{j,t-1}^N) + \Sigma_{k=0}^2 b_{sk} \Delta S_{j,t-k}^N / \hat{A}_{j,t-k}^N + b_c \Delta \ln C_{j,t} + LIQ_{j,t} + Q\tau + \theta^I + \theta_{1,t}^I + \theta_{2,t}^I + \theta_{3,t}^I + w_{j,t},$$

where $V_{j,t}^N$, $\hat{A}_{j,t}^N$, and $S_{j,t}^N$ denote the nominal inventory stock, the beginning-of-period nominal total assets, and nominal sales in period t, respectively.

A lagged dependent variable is included in the regression to capture short-run dynamics. The coefficient of ln $(V_{j,t-1}/S_{j,t-1})$ is expected to be negative, since a rise in the ratio calls for a downward adjustment in the inventory stock in the following period, as implied by an error correction mechanism based on a stable inventories-sales ratio over time.

An unexpected increase in sales will lower inventories, buffering production from sales shocks. When sales growth is largely unpredicted, the current sales growth primarily reflects unexpected sales shocks.[7] Considering that it may take time for firms to align their inventories with sales shocks by adjusting production, one-quarter-lagged sales growth may also have a negative coefficient. We include a cost variable, $\Delta \ln C_{j,t}$, to account for the effect of the change in production cost on inventory adjustments.

Other important factors are represented by the $Q\tau$ term. Firms with higher interest costs relative to debts will have smaller inventories as buffers, since inventories are more costly to maintain for them than for other firms. To account for such variations in inventory investment across firms, we use the interest payments–total debt ratio. Also, to capture that firms adjust their target inventories relative to sales upwards as markups increase as suggested by Bils and Kahn (2000), the sales–total costs ratio can be included as a proxy for the markup, assuming a

[7] Instead of decomposing actual sales into expected and unexpected components, which introduce the econometric issues of estimating a sales equation and generated regressors problem, we use actual sales data. The sales level can be treated as a proxy for the expected sales level. Actual sales growth can be considered a proxy for unexpected sales growth if the log of sales is approximated by a random walk process.

constant-return-to-scale production technology.[8] We can also include the current change in liquid assets to account for inventories as buffers for internal finance in the short run. If inventories and liquid assets are substitutes as sources of internal finance, inventory investment should be negatively related to liquid asset changes in the short run. Finally, we include a monetary policy stance measure to capture the direct impacts of policy on inventory investment.

IV. The Data

We use two different quarterly panel datasets, constructed from Compustat, for the period 1975–97.[9] To link panel data and time series consistently, we use the calendar (not fiscal) year for each firm's data. The main dataset is composed of S&P 500 firms that were in the S&P industrial or transportation index list in any of the years 1978, 1987, and 1997. A firm is included in our sample if inventories, sales, and liquid assets are reported and positive for more than 12 consecutive quarters. We exclude financial firms and utilities, because they do not produce physical products (and thus no significant inventories). After these screenings, we are left with an unbalanced panel that contains 659 firms in 53 industries categorized by the two-digit Standard Industrial Classification (SIC) code. The second dataset is constructed to match the S&P firms as closely as possible, except that firms in this set are smaller. This set comprises 689 non-S&P firms in 46 industries by two-digit SIC code (see, for the firm selection criterion, Appendix B). The sample period starts from 1975, before which the availability of quarterly observations is limited. Figure A.1 in Appendix B lists the number of S&P and non-S&P firms for each quarter for the period.[10]

Inventories represent merchandise for resale and materials and supplies for use in production of revenue (Compustat quarterly item #38). We use quarterly figures for sales and total assets. Liquid assets are defined as cash plus short-term investments, and the cost variable is measured by the growth of real cost of goods sold.[11] This cost variable is highly correlated with sales growth (correlation ≈ 0.88) but contains innovations in the production-side information because markups vary over business cycles. We also use the interest expense–total

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[8] Bils and Kahn (2000) emphasize a countercyclical markup that allows procyclical factor utilization to affect the cost of inputs, rather than a procyclical marginal cost that may imply a decreasing-return-to scale production technology.

[9] Both datasets are compiled from three types of Compustat files: (i) industry files for currently active firms on the NYSE or on the American Stock Exchange; (ii) full coverage files for currently active firms listed in other stock exchanges (mostly NASDAQ); and (iii) research files for all kinds of firms that were once included in Compustat but are no longer active.

[10] The number of S&P firms is stable over time except for the initial few years, while that of non-S&P firms shifts up in the early 1980s indicating that there are more active firms with consecutive observations in later periods.

[11] The cost variable covers the direct cost of production such as materials, labor, and overhead. For some firms, it also includes commercial expenses of operation (expenses not directly related to production) when they are not broken out separately.

liabilities ratio to reflect the financial cost and the sales–cost of goods sold ratio to account for the markup effect.

Table 1 displays the summary statistics of the main variables for S&P and non-S&P firms. Inventories are more volatile than sales in levels (across time and firms), but the converse is true in growth rates (mainly across firms). The *V/S* ratio on average is 0.61 for S&P firms and 0.77 for non-S&P firms, possibly indicating that big firms can manage inventories more efficiently than smaller firms can. Inventory growth and sales growth, on average, are higher for non-S&P firms than for S&P firms, reflecting the fast growth of smaller firms. The large variations of inventory growth relative to its mean are more pronounced for S&P firms than for non-S&P firms. Non-S&P firms tend to hold more liquid assets relative to total assets than do S&P firms (on average, 9.7 percent versus 7.3 percent). The liquid assets–total assets ratio is more stable for S&P firms than for non-S&P firms. The variation of liquid asset growth is about three times as high as that of sales growth in both datasets (e.g., 0.680 versus 0.199 for S&P firms). The interest cost ratio and the sales-cost ratio (markup) are similar for S&P and non-S&P firms.

Aggregate time series are from FRED (Federal Reserve Economic Data) at the Web site of the Federal Reserve Bank of St. Louis. The consumer price index (CPI) is used to convert current dollars into 1992 dollars in constructing real variables. The policy stance in period t is measured by the change in the Federal funds rate, ΔFFR_t, considered as a good indicator for the Fed's policy stance (Bernanke and Blinder, 1992; Christiano, Eichenbaum, and Evans, 1996).

Panel A of Figure 1 shows the cross-section means of inventories and sales growth, all in real terms, excluding extreme observations of more than 400 percent per year. The growth rate is measured by the annualized average growth (in fraction) over the preceding four quarters to control for seasonality. Sales growth tends to be followed by inventory growth in a few quarters. Vertical lines depict the business cycle peaks and troughs. During a peak-to-trough movement, with a sharp decrease in sales, inventory growth declines but not as much as sales growth declines. Panel A also depicts the annualized change in the liquid assets–total assets ratio. It is notable that the liquidity measure rose on the eve of the 1982 recession and then followed a large swing around the business cycle trough, which was more pronounced for non-S&P firms. Panel B depicts the Federal funds rate change as a measure of the monetary policy stance: a higher value represents a tighter policy stance. It was volatile in the early 1980s with the nonborrowed reserve targeting and the Fed's antiinflationary policy, and has become smooth with the Federal fund rate targeting since the-mid 1980s.

Figure 2 shows distributed movements of the policy stance, inventory growth minus sales growth, and liquidity position before and after the start of the 1982 and 1991 recessions up to six quarters. Panel A indicates that the policy stance becomes tighter as the economy nears the peak and looser as it deepens into recession. Panel B shows that inventory growth relative to sales growth goes up in the early stage of a recession and then declines as the recession deepens, except for inventory adjustments by non-S&P firms in the 1991 recession. In panel C, liquidity growth rises before entering a recession and then shows a "J-shape" adjustment after the business cycle peak, which is more pronounced for the 1982 recession.[12] The increase in liquidity before recessions may reflect the precautionary demand for liquidity upon a persistent tighter policy: for example, the liquidity measure increased 0.4 percentage point for S&P firms and 1.3 percentage point for non-S&P firms, one quarter prior to the onset of the 1982 recession. Comparing panels B and C gives the impression that inventory growth may not bear a positive link to liquidity.

V. Regression Results

We begin by determining whether inventories and sales are closely linked in level terms. Then we estimate baseline regressions that explain, in dynamic specifications, inventory investment (or growth) by sales growth, the sales-inventory ratio, cost shocks, and the liquidity constraint whose effects can be time-varying. We also estimate extended regressions to incorporate the effects of individual interest costs and markups. In addition, we estimate regressions to obtain implications for the different impacts of monetary policy on inventory adjustments across different firm sizes or bond ratings. For comparison purposes, we also examine the effect of cash flow on inventory investment. Finally, we provide robustness checks.

A. Regressions for the Inventory-Sales Relation

To see whether inventories and sales are closely linked, as predicted by a target inventory model, we regress the log of the inventory stock on the log of sales. We control for the inventory management progress over time, which is reflected in α_t in equation (9), either by quarter-year dummies or by demeaning variables for the cross-section average. Standard errors are corrected using White's method to account for heteroskedastic errors of unknown forms.

Table 2 shows the results of regressions with the S&P 500 firm data (columns 2–5) and with non-S&P firm data (columns 6–9), respectively. The adjusted R^2 is about 0.70 for S&P and 0.52 for non-S&P firms, implying that the inventory-sales link is looser for non-S&P firms. The estimated coefficients and standard errors are almost identical, whether the specification is in the level form or in the cross-section average deviation form. For S&P firms, the estimated coefficient on the log of sales is close to unity, although significantly less than unity at the 1 percent level.[13] For non-S&P firms, the estimated sales coefficient is in the range of 0.80–0.86, smaller than that for S&P firms. In addition, we estimate regressions allowing the sales coefficient to vary from year to year. The results, summarized in Figure 3, suggest a stable link

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[12] The J-shape adjustment takes place perhaps because liquidity holding is more costly with higher interest rates in the early stages of recessions following tighter policy but becomes less costly with lower interest rates as the effect of tighter policy sheds out and the recession deepens.

[13] If firms target expected sales, the use of actual sales in place of expected sales may involve a bias because of the correlation between the regressor and the error term. To control for this possibility, we also estimate the regression by two-stage least squares (2SLS) using the four lags of the regressor as instruments. Dummy variables are also instruments if they are the second-stage regressors. We obtain an almost identical estimate from this exercise.

between inventories and sales over time, which can be taken as supporting evidence that firms tend to keep inventories roughly proportional to sales over the long run.

B. Regressions for the Dynamic Adjustment of Inventories

The inventory equation is specified in the difference of the log of inventories, as in equation (10). The liquidity variable is measured by the beginning-of-quarter (i.e., one-quarter lagged) ratio of liquid assets to total assets. Baseline regressions (a)–(f) include key variables, and extended regressions (g)–(i) include additional variables.

We first estimate regressions (a)–(c), assuming that the liquidity constraint has a time-invariant effect on inventory investment. Regression (a) includes a lagged dependent variable, the lagged inventory–sales ratio in log, current sales growth, and the liquidity variable. Regression (b) adds the lagged values of sales growth and current cost growth. Regression (c) is slightly less constrained than regression (b) in that it uses the lagged values of inventory and sales separately in place of the lagged inventory–sales ratio. All regressions include the quarter-industry effects, accounting for the fixed-industry effect and the industry differential in seasonality.[14] Standard errors are computed using White's correction for heteroskedasticity.

Table 3 summarizes the results for S&P firms (columns 2–4) and non-S&P firms (columns 5–7), respectively. The lagged dependent variable shows a negative coefficient, indicating an adjustment with oscillations over time. The coefficient of ln $(V_{j,t\text{-}1}/\ S_{j,t\text{-}1})$ in regressions (a) and (b) is negative and statistically significant, indicating the adjustment to revert to a target inventory-sales ratio. This coefficient is almost the same as the coefficients of ln $V_{j,t\text{-}1}$ and ln $S_{j,t\text{-}1}$ in regression (c). Hence, we use the inventory–sales ratio in Table 4 and in what follows.

The sales growth effect on inventory investment shows different patterns between S&P and non-S&P firms. For S&P firms, the current and one-quarter-lagged sales growths reduce inventory investment, consistent with the buffer stocks (or production smoothing) argument. Inventory investment responds positively to sales growth with a further lag. In contrast, for non-S&P firms, inventory investment increases with the current sales growth and decreases with the one-quarter-lagged sales growth. This may be because smaller firms are on the earlier stage of growth so their current sales changes are more indicative of future sales growth. Or, it may be because in the short run smaller firms can adjust faster within a capacity limit than bigger firms can. Hence smaller firms may better absorb the effect of unexpected sales on inventories.[15]

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[14] If a regression includes fixed firm effects in addition to a set of time-liquidity dummies, it controls for most of the cross-section effects, given the time-varying effect on cross-section samples. Also, fixed-firm effects can be correlated with a lagged dependent variable. As a result, the regression may unduly measure the time-varying effect of liquidity on cross-section samples.

[15] The correlation coefficient between the log difference of inventories and that of sales is –0.15 for S&P firms and –0.02 for non-S&P firms.

The coefficient estimate of the current cost growth is negative and marginally significant for S&P firms and highly significant (t-value <–6) for non-S&P firms, implying that a higher cost growth reduces inventory investment, consistent with the inventory theory of production-cost smoothing. Adding the cost growth variable has only a small impact on the coefficient estimate of the current sales growth, mainly for S&P firms, indicating that the multicollinearity problem arising from a high correlation between sales growth and cost growth is not serious.

The coefficient of the liquidity variable, which is our main interest, is in the range of 0.14–0.16, with a t-value greater than 10. We interpret this to mean that inventory investment is significantly liquidity-constrained for the whole sample. The difference in liquidity coefficients between the two groups of firms is small: if anything, it is slightly larger for S&P firms than for non-S&P firms, possibly because smaller firms, being more vulnerable to financial distress, hold more liquid assets relative to big firms (the liquid assets–total assets ratio = 0.10 versus 0.07, Table 1), which renders smaller firms less liquidity-constrained.

Now we allow the effect of liquidity constraints to vary over time. Regression (d) includes the liquidity variable multiplied by $(1\text{-}Rdum_t)$ and by $Rdum_t$, respectively, where $Rdum_t$ is a recession dummy that takes the value one if the date in question belongs to recession and credit crunch periods of 1975, 1981:4–82:4, and 1990:3–91:4. Regression (e) includes a set of year-liquidity dummies, while regression (f) includes a set of time-liquidity dummies. Table 4 reports the results, except for the coefficient estimates of time-liquidity dummies in regressions (e) and (f), which are shown in Figure 4.

Regression (d) indicates that the effect of the liquidity constraint during recessions is smaller than during nonrecessionary periods for S&P firms and insignificant for non-S&P firms, while implications from other variables remain the same. Figure 4 depicts the time-varying liquidity effects on inventory growth. The liquidity effect, when assumed to be the same within a year (panels A and B), is significantly positive for most periods, with a few exceptions. Both S&P 500 and non-S&P firms show insignificant effects during 1975:4, 1982, and 1991, all of which were recessions. The absence of the liquidity effect is observed for non-S&P firms around the brief recession of 1980 and for S&P firms during 1995–97. The same pattern emerges when the effect of the liquidity constraint is allowed to vary from quarter to quarter (panels C and D): despite more variations over time, inventory investment rises with liquidity during most periods other than recessions.

These results can be explained as follows. At the onset of a recession following tighter policy, a sharp drop in sales, which is typically unexpected, results in a brief period of unplanned inventory buildup. As the recession deepens, however, firms reduce their inventory investment with lower sales. Furthermore, firms conserve cash before entering a recession to hedge against future financial distress. As tighter monetary policy gains momentum in the early stage of the recession, the demand for liquidity can decrease. In the midst of the recession when the effects of monetary tightening are weakened, the demand for liquidity tends to rise again as the interest rate falls. Inventory investment thus has little or no dependence on liquid assets during recessions.

Table 5 presents the results of extended regressions (g)–(i), which include additional firm-specific variables: the interest expense–total liability ratio, log of the sales–cost of goods sold ratio as a proxy for markups, and a measure of liquid asset growth, $\Delta \ln m_{j,t}$. The estimated coefficient of $\Delta \ln m_{j,t}$ is significantly negative (t-value <–10), supporting that inventories and liquid assets are substitutes as internal sources of finance.[16] Thus, an increase in one of the two reduces the other in a short period, consistent with previous findings (Friedman and Kuttner, 1993; Carpenter, Fazzari, and Petersen, 1994; Choi and Kim, 2000). Allowing for the quarter-varying liquidity effects yields almost identical estimates as in regression (i), except for the liquidity coefficients (not reported). Figure 5 shows the time-varying effects of the liquidity constraint in regression (i), similar to those in baseline regressions.

C. Monetary Policy Effects and Access to Financial Markets

A stylized finding from time-series analysis is that, following tighter monetary policy, inventory investment initially rises before falling substantially in a few quarters (Friedman and Kuttner, 1993; Christiano, Eichenbaum, and Evans, 1996). In addition, inventory growth declines faster and more sharply for small firms than for big firms (Gertler and Gilchrist, 1994). At the firm level, we estimate the direct effect of monetary policy on inventory investment by introducing the change in the Federal funds rate into our regressions.

Table 6 reports the results of three regressions. Regressions (c′), (g′-1) include the current and lagged values of the Federal funds rate change, $\{\Delta FFR_{t-k}\}_{k=0}^{8}$, in place of the liquidity variable, and regression (g′-2) adds these variables to regression (g). Since firm-specific financial variables, the corporate liquidity position and the interest cost ratio, can be directly affected by monetary policy, we use these variables demeaned for the cross-section average. These financial variables have the expected signs and are statistically significant.

Figure 6 depicts the responses of inventory growth to tighter policy, which are consistent with the earlier findings from the time series analysis (e.g., Friedman and Kuttner, 1993; Bernanke and Gertler, 1995): upon tighter policy, initial increases in inventory investment are followed by substantial decreases, as tighter policy gains momentum after a few quarters. Moreover, the decreases are quicker and stronger for non-S&P firms than for S&P firms.[17] This result is in line with the earlier findings from the Quarterly Financial Report data (Gertler and Gilchrist, 1994; Bernanke, Gertler, and Gilchrist, 1996).

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[16] If firms decide on inventory investment and liquid asset holdings at the same time, as noted by Kashyap in his comment to Carpenter, Fazzari, and Petersen's (1994) paper, the use of current liquid asset growth can lead to a simultaneity bias. However, using the instrumental variables method to address this problem did not affect our results qualitatively.

[17] This result is little affected when allowing for time-varying coefficients of demeaned liquidity, which appear to be smaller and less significant than time-varying coefficients in earlier regressions. They show a similar time-varying pattern with one exception: the year-(demeaned) liquidity coefficient is significant around the recessions of 1982 and 1991 for S&P 500 firms.

It is interesting to see whether access to financial markets affects the strength of liquidity constraints on inventory investment. This exercise is motivated by the bank-dependence hypothesis (KLS, 1994), which holds that inventories of bank-dependent firms fall more sharply in response to tighter policy than do those of firms with sufficient internal funds or access to financial markets. KLS define a firm as bank-dependent when two conditions are satisfied: (i) the firm has a small amount of cash on hand, and (ii) it cannot raise money in a public market.

At first glance, our liquidity coefficient estimates for S&P and non-S&P firms do not suggest that liquidity affects big and smaller firms differently. To take a closer look, using the S&P senior debt rating as a proxy for differential access to financial markets, we classify firms into "high-grade" firms (i.e., firms with investment-grade ratings) and "low-grade" firms for 1985:1–97:4, the starting date of which is dictated by the availability of debt ratings from Compustat. We estimate regressions (c″) and (g″-1), which add to regressions (c) and (g) a variable defined by $\hat{m}_{j,t} / \hat{A}_{j,t}$ multiplied by a bond market access dummy, $Bdum_{j,t}$, which takes the value one if firm *j* has a S&P senior debt rating of BBB or higher at time *t*.

Table 7 shows that the liquidity coefficient is in the range of 0.12–0.16 and highly significant. However, the coefficient of $(\hat{m}_{j,t} / \hat{A}_{j,t}) \cdot Bdum_{j,t}$ is small relative to the liquidity coefficient and statistically insignificant, indicating no significant difference in the liquidity effect on inventory investment between high- and low-grade firms.[18] Further, to examine differential effects during nonrecessionary periods and recessions, we estimate regression (g″-2), which includes four cross terms for interacting the recession and bond rating dummies with the liquidity variable. The first two capture the liquidity effects of the firms with and without bond ratings during nonrecessionary periods, while the last two capture the liquidity effect of those firms during the recession of 1990–91. For both S&P and non-S&P firms, the liquidity effect is significant only during nonrecessionary periods, regardless of the firm's bond rating. If anything, it is more significant for firms without bond ratings during nonrecessionary periods.

The results in Table 7, however, cannot be taken as evidence against the bank-dependence hypothesis, since smaller firms tend to keep larger reserves of liquidity relative to total assets, violating the first of the two conditions for the validity of the hypothesis. Despite a similar liquidity elasticity of inventory growth, smaller firms show a greater decline in inventory investment when the money market is tight (Figure 6). This is because liquid assets decrease more for smaller firms than for big firms after tighter policy, which reinforces the adverse effect of tighter policy on inventory investment after a few quarters. Thus, we suggest that the asymmetry in inventory investment across different firms takes place because of the different

[18] Low-grade observations are more heavily concentrated in non-S&P firms (53 percent of the sample) than in S&P firms (30 percent of the sample). The regression results are robust to alternative measures of debt rating, including the S&P common stock ranking, commercial paper rating, and subordinated debt rating.

impacts of monetary policy on liquidity adjustments, rather than the difference in liquidity coefficients across firms, which is also consistent with the findings in the following section.

D. Cash Flow and Inventory Investment

So far we have focused on the link between liquidity and inventory investment. If liquidity enters into the production function as a production factor, the sensitivity of inventory investment to liquidity will depend on production technologies, not on firms' financial status, consistent with our empirical findings.

Earlier studies have suggested that inventory investment or investment is less sensitive to cash flow for financially stronger firms.[19] Cash flow, defined as income before extraordinary items plus depreciation and amortization, is more like the net revenue of the firm resulting from operating activities. Firms can mitigate the effect of cash flow shocks by adjusting investing activities such as capital expenditures and/or by financing activities. We expect firms with better access to financial markets or committed bank loans to be better able to absorb cash flow shocks through liquidity management, particularly through financing activities. Inventory investment, therefore, can be less sensitive to cash flows for firms with bond ratings, whereas the sensitivity of inventory investment to liquidity is little affected by bond ratings.

To examine the link between cash flow and inventory investment and firms' credit-worthiness, we use the ratio of the one-period-lagged cash flow to the beginning-of-period total assets in place of the liquidity variable. Table 8 summarizes the effect of cash flow on inventory investment, and Figure 7 depicts cash flow coefficients over time. To allow for differential impacts depending on the economy's business cycles and firms' creditworthiness, we use dummies for recessions and bond ratings, respectively.

The results for S&P firms suggest that cash flow positively affects inventory investment for most periods, but less so for recessions (regressions (j), (k) and Figures 7A and 7C). Inventory investment is less affected by cash flows when firms have bond ratings, which is more pronounced during nonrecessionary periods than during recessions (regression (l)). For non-S&P firms, cash flow positively affects inventory investment only during nonrecessionary periods, which is statistically more significant for firms without bond ratings (although the point estimate is higher for non-S&P firms with bond ratings). We interpret this to mean that cash flows have little impact on inventory investment during recessions, because firms have unplanned inventory buildups and have conserved cash before going into recessions.

[19] For example, a greater sensitivity of investment to cash flow is found for low-dividend firms than for high-dividend firms by Fazzari, Hubbard, and Peterson (1988), and for firms without loan commitments than for those with loan commitments by Morgan (1999).

E. Robustness Checks

Compared with KLS, we observe a different group of firms at higher frequency. Firms can adjust inventories and liquid assets within one or two quarters, instead of over a full year. Further, at an annual frequency, much of the variability in flow variables, such as inventory investment and sales, is obscured. Thus, inventory investment behavior can be captured more adequately at quarterly, rather than at annual, frequency. To see whether the difference between our results and those of KLS is due to the difference in data frequency, we also estimate panel regressions using the annual data for the same firms. In doing this, we restrict our sample to the majority of firms (approximately 76 percent of S&P 500 firms and 60 percent of non-S&P firms of the sample) whose fiscal years end in the fourth quarter. Table 9 and Figure 8 show the results. The time-varying liquidity coefficient is insignificant for the recession years of 1982 and 1991, although significant for 1975 for S&P firms, and qualitatively not much different from the results with the quarterly data. However, the coefficients on annual sales growth, whose unexpected component is smoothed out, become positive, and those on cost factors become insignificant. Moreover, we find that excluding the 1990s samples, considering that the KLS dataset ends at 1989, does not affect the result qualitatively.

We assess the robustness of our results further as follows. First, we estimate an alternative regression model specified in ratio form, as in equation (10′), but we obtain qualitatively similar results for the liquidity effect. These are summarized in Table 10 and Figure 9. Second, to see whether our results are driven by a small number of extreme observations, we exclude observations in the 1 percent tails for each of inventory growth and sales growth. This exercise provides qualitatively the same results for liquidity and policy shock effects.[20] Lastly, to check whether a sample selection bias associated with the selection of firms with at least 12 consecutive observations is responsible for our findings, we use alternative consecutive observations of 8 and 30 quarters. This exercise yields little change in the results.

VI. Concluding Remarks

Two factors can explain our finding that inventory investment is least liquidity-constrained during recessions. First, planned inventory investment depends positively on liquid asset holdings, which explains actual inventory data during nonrecessionary periods when firms can mostly anticipate sales. However, markets typically cannot foresee the sharp drop in sales that occurs at the start of recessions. These unexpected sales shocks explain why inventories rise at this point, reflecting the discrepancy between planned and actual inventory investment. Second, given the endogeneity of bank loans that provide firms with a form of liquidity insurance through committed lines of credit, firms raise their demand for liquidity to fend off future financial distress in the face of tighter policy. Thus firms with unplanned inventory buildups have less need for inventory investment, but they have more funds raised upon tighter policy to

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[20] The results for S&P firms are quite similar to the whole sample results. The results for non-S&P firms, however, suggest a somewhat different adjustment pattern: the lagged dependent variable becomes insignificant, and the current sales growth coefficient becomes much smaller (the details are available from the authors upon request).

hedge against future financial distress. This behavior makes inventory investment less prone to liquidity constraints during recessions. In contrast, Bernanke (1994) and Bernanke, Gertler, and Gilchrist (1996) conjecture that firms increase liquidity to finance inventory buildups at the onset of recessions.

The findings of this paper are also consistent with the view of a recent article in *Business Week* ("In Today's Corporate America, Cash is King," March 12, 2001). The article suggests that, with the economy stalling and fears of recession rising, firms are increasingly concerned about protecting their cash reserves and are trying to conserve cash before it is too late. The article also suggests that firms have built a financial safety net to hedge against possible financial distress from the credit crunch and bankruptcies that tend to accompany a recession. This precautionary cash management may not be new, although the intensity could vary over time as firms learn from past recession experiences.[21]

It has been noted that going into the current economic storm, firms had more cash on their balance sheets than before the last four recessions (see the aforementioned article in *Business Week*). We find from regression results for the two sub-sample periods of 1975–89 and 1990–97 (not reported) that the liquidity effects on inventory investment appear weaker in the 1990s than in earlier periods. It will be interesting, in future research, to have a deeper look at this phenomenon, which may be attributable to a stronger endogeneity of bank loans under interest rate targeting[22] and firms' broader choices of financing methods with more advanced financial markets.

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[21] Also, investors in financial markets understand that the relative performance of bonds, equities, commodities, and cash follows a familiar, if rough, pattern (*The Economist*, April 21–27, 2001). This pattern suggests that, after the economic expansion nears its peak, "as central banks raise interest rates to quell inflation, cash is king."

[22] Choi and Oh (2000) also suggest that in the face of tighter policy, investors increase money holdings in the short run if the money supply is partially endogenous. Using the U.S. time series data, they provide evidence that the demand for M1 depends positively on a tighter policy shock during the recent Federal funds rate targeting period.

Table 1. Summary Statistics of the Main Variables for S&P 500 and Non-S&P Firms

Variable	N (no. of obs.)	Mean	Standard deviation	Minimum (1%)[a]	1st quarter	Median	3rd quarter	Maximum (99%)[a]
A. S&P 500 firms								
$\ln V_{j,t}$	44,536	5.328	1.452	−5.870 (−1.436)	4.537	5.441	6.286	9.401 (8.390)
$V_{j,t} / S_{j,t}$	44,843	0.613	3.620	0.002 (0.033)	0.298	0.512	0.753	460.8 (1.927)
$\ln S_{j,t}$	45,567	6.127	1.307	−4.853 (−2.846)	5.318	6.179	6.982	10.39 (9.264)
$\Delta\ln V_{j,t}$	44,536	0.003	0.176	−6.251 (−0.492)	−0.052	0.002	0.059	3.025 (0.498)
$\Delta\ln S_{j,t}$	45,190	0.011	0.199	−6.586 (−0.548)	−0.057	0.014	0.087	2.836 (0.540)
$\hat{m}_{j,t} / \hat{A}_{j,t}$	44,613	0.073	0.088	0.000 (0.001)	0.017	0.040	0.096	0.888 (0.430)
$\Delta\ln C_{j,t}$	42,989	0.011	0.201	−5.509 (−0.538)	−0.057	0.014	0.085	4.762 (0.542)
Interest cost[b]	41,033	−4.696	0.668	−13.47 (−7.168)	−4.940	−4.578	−4.302	−1.489 (−3.572)
Markup[b]	43,915	0.432	0.306	−2.420 (0.024)	0.241	0.359	0.542	5.159 (1.503)
$\Delta\ln m_{j,t}$	44,623	0.006	0.680	−6.760 (−2.044)	−0.243	0.002	0.240	7.434 (2.131)
B. Non-S&P firms								
$\ln V_{j,t}$	37,029	3.018	1.295	−5.073 (−0.721)	2.299	3.210	3.903	9.401 (8.390)
$\ln S_{j,t}$	37,870	3.667	1.089	−4.948 (−0.476)	3.054	3.769	4.397	10.39 (9.264)
$V_{j,t} / S_{j,t}$	38169	0.771	7.095	0.000 (0.028)	0.349	0.605	0.895	1124.8 (3.045)
$\Delta\ln V_{j,t}$	37,029	0.009	0.219	−4.642 (−0.576)	−0.061	0.007	0.080	4.598 (0.582)
$\Delta\ln S_{j,t}$	37,870	0.014	0.286	−8.382 (−0.824)	−0.077	0.017	0.110	6.922 (0.825)
$\hat{m}_{j,t} / \hat{A}_{j,t}$	36,972	0.097	0.120	0.000 (0.001)	0.017	0.049	0.132	0.871 (0.546)
$\Delta\ln C_{j,t}$	36,220	0.016	0.277	−4.810 (−0.781)	−0.077	0.016	0.112	4.258 (0.823)
Interest cost[b]	31,899	−4.649	0.810	−9.947 (−7.534)	−4.939	−4.488	−4.154	−0.994 (−3.305)
Markup[b]	36,910	0.422	0.331	−5.749 (0.076)	0.233	0.349	0.532	4.372 (1.548)
$\Delta\ln m_{j,t}$	36,975	0.010	0.852	−6.760 (−2.044)	−0.312	−0.006	0.302	7.714 (2.710)

Notes: Distributions of variables for the 1975:1–97:4 period are computed with the S&P 500 data (659 firms) in panel A and the non-S&P 500 data (689 firms) in panel B. The CPI is used to convert all current dollars into 1992 dollars.

[a] Figures in parentheses are 1 percentile (99 percentile) values for the minimum (maximum) column.

[b] Interest cost indicates the log of the interest expenditure–total liability ratio, and markup indicates the log of the sales–cost of goods sold ratio.

Table 2. Regressions for the Inventory-Sales Relation

Independent Variable	S&P 500 firms				Non-S&P 500 firms			
	Level		Deviation		Level		Deviation	
$\ln S_{jt}$	0.948** (0.004)	0.892** (0.009)	0.947** (0.004)	0.896** (0.009)	0.868** (0.005)	0.798** (0.009)	0.866** (0.005)	0.804** (0.009)
Quarter-year effects	Yes	Yes	No	No	Yes	Yes	No	No
Fixed-firm effects	No	Yes	Yes	Yes	No	Yes	No	Yes
$\bar{R}^2$	0.705	0.705	0.705	0.705	0.532	0.532	0.522	0.522
N	45,815	45,815	45,815	45,815	38,533	38,533	38,533	38,533

Notes: The regressions are performed with the S&P 500 data (659 firms) and with the non-S&P 500 data (689 firms) for the 1975:1–97:4 period. The dependent variable is $\ln V_{jt}$. $\bar{R}^2$ excludes variance explained by the fixed-firm effects. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 3. Baseline Regressions with Time-Invariant Liquidity Effects

Independent variable	S&P 500 firms (a)	S&P 500 firms (b)	S&P 500 firms (c)	Non-S&P 500 firms (a)	Non-S&P 500 firms (b)	Non-S&P 500 firms (c)
$\Delta \ln V_{j,t-1}$	−0.094** (0.014)	−0.096** (0.014)	−0.096** (0.014)	−0.075** (0.018)	−0.055** (0.018)	−0.055** (0.018)
$\ln V_{j,t-1}/S_{j,t-1}$	−0.037** (0.003)	−0.037** (0.003)	—	−0.044** (0.003)	−0.042** (0.003)	—
$\ln V_{j,t-1}$	—	—	−0.038** (0.003)	—	—	−0.043** (0.003)
$\ln S_{j,t-1}$	—	—	0.035** (0.004)	—	—	0.040** (0.004)
$\Delta \ln S_{j,t}$	−0.049** (0.010)	−0.036* (0.018)	−0.038* (0.018)	0.044** (0.011)	0.117** (0.029)	0.117** (0.029)
$\Delta \ln S_{j,t-1}$	—	−0.079** (0.014)	−0.079** (0.014)	—	−0.037** (0.008)	−0.036** (0.008)
$\Delta \ln S_{j,t-2}$	—	0.068** (0.010)	0.068** (0.010)	—	0.010 (0.008)	0.010 (0.008)
$\hat{m}_{j,t} / \hat{A}_{j,t}$	0.163** (0.013)	0.152** (0.013)	0.143** (0.013)	0.139** (0.014)	0.139** (0.014)	0.135** (0.014)
$\Delta \ln C_{j,t}$	—	−0.030† (0.016)	−0.030† (0.016)	—	−0.089** (0.012)	−0.089** (0.029)
$\bar{R}^2$	0.128	0.145	0.145	0.078	0.082	0.082
N	43,702	41,775	41,775	36,140	34,677	34,677

Notes: The regressions are performed with the S&P 500 data (659 firms in 53 industries) and the non-S&P 500 data (689 firms in 46 industries) for the 1975:4–97:4 period. The dependent variable is $\Delta \ln V_{j,t}$, and the liquidity measure is $\hat{m}_{j,t} / \hat{A}_{j,t}$, defined as the beginning-of-period ratio of liquid assets to total assets. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 4. Baseline Regressions with Time-Varying Liquidity Effects

Independent variable	S&P 500 firms (d)	S&P 500 firms (e)	S&P 500 firms (f)	Non-S&P 500 firms (d)	Non-S&P 500 firms (e)	Non-S&P 500 firms (f)
$\Delta \ln V_{j,t-1}$	-0.097^{**}	-0.097^{**}	-0.097^{**}	-0.057^{**}	-0.058^{**}	-0.057^{**}
	(0.014)	(0.014)	(0.014)	(0.018)	(0.018)	(0.018)
$\ln (V_{j,t-1}/S_{t-1})$	-0.037^{**}	-0.040^{**}	-0.040^{**}	-0.042^{**}	-0.042^{**}	-0.042^{**}
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta \ln S_{j,t}$	-0.037^{*}	-0.036^{**}	-0.035^{*}	0.117^{**}	0.116^{**}	0.117^{**}
	(0.018)	(0.018)	(0.018)	(0.029)	(0.029)	(0.029)
$\Delta \ln S_{j,t-1}$	-0.080^{**}	-0.084^{**}	-0.083^{**}	-0.038^{**}	-0.040^{**}	-0.041^{**}
	(0.014)	(0.014)	(0.014)	(0.008)	(0.008)	(0.008)
$\Delta \ln S_{j,t-2}$	0.068^{**}	0.065^{**}	0.065^{**}	0.009	0.008	0.007
	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)	(0.008)
$\hat{m}_{j,t} / \hat{A}_{j,t} \times (1 - Rdum_t)$	0.162^{**}	—	—	0.159^{**}	—	—
	(0.014)			(0.015)		
$\hat{m}_{j,t} / \hat{A}_{j,t} \times Rdum_t$	0.071^{**}	—	—	-0.013	—	—
	(0.025)			(0.027)		
$\boldsymbol{LIQ_{j,t}}$	—	[Fig. 4A]	[Fig. 4C]	—	[Fig. 4B]	[Fig. 4D]
$\Delta \ln C_{j,t}$	$-0.030^{\dagger}$	-0.031^{*}	-0.031^{*}	-0.089^{**}	-0.090^{**}	-0.093^{**}
	(0.016)	(0.016)	(0.016)	(0.029)	(0.029)	(0.029)
Time-varying liquidity effects	Recession dummy	Year-liquidity dummies	Time-liquidity dummies	Recession Dummy	Year-liquidity dummies	Quarter-liquidity dummies
$\overline{R}^2$	0.145	0.149	0.152	0.084	0.086	0.089
N	41,775	41,775	41,775	34,677	34,677	34,677

Notes: The regressions are performed with the S&P 500 data (659 firms in 53 industries) and the non-S&P 500 data (689 firms in 46 industries) for the 1975:4–97:4 period. The dependent variable is $\Delta \ln V_{j,t}$, and the liquidity measure is $\hat{m}_{j,t} / \hat{A}_{j,t}$, defined as the beginning-of-period ratio of liquid assets to total assets. $Rdum_t$ is a dummy for recession periods that takes value one for 1975:4, 1981:4–82:4; and 1990:3–91:4. Time-varying liquidity effects ($\boldsymbol{LIQ_{j,t}}$) are captured by a set of time-liquidity dummies whose coefficient estimates are depicted in Figure 4. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 5. Extended Regressions with and without Time-Varying Liquidity Effects

Independent variable	S&P 500 firms (g)	S&P 500 firms (h)	S&P 500 firms (i)	Non-S&P 500 firms (g)	Non-S&P 500 firms (h)	Non-S&P 500 firms (i)
$\Delta\ln V_{j,t-1}$	-0.109^{**} (0.016)	-0.112^{**} (0.016)	-0.110^{**} (0.016)	-0.073^{**} (0.021)	-0.072^{**} (0.022)	-0.076^{**} (0.021)
$\ln (V_{j,t-1}/S_{j,t,-1})$	-0.035^{**} (0.002)	-0.034^{**} (0.002)	-0.037^{**} (0.003)	-0.036^{**} (0.004)	-0.036^{**} (0.004)	-0.036^{**} (0.004)
$\Delta\ln S_{j,t}$	-0.071^{**} (0.014)	-0.034^{**} (0.021)	-0.072^{**} (0.015)	0.033^{**} (0.015)	0.106^{**} (0.034)	0.029^{**} (0.015)
$\Delta\ln S_{j,t-1}$	-0.086^{**} (0.015)	-0.077^{**} (0.015)	-0.090^{**} (0.015)	-0.042^{**} (0.008)	-0.034^{**} (0.008)	-0.046^{**} (0.008)
$\Delta\ln S_{j,t-2}$	0.078^{**} (0.011)	0.082^{**} (0.011)	0.075^{**} (0.011)	0.007 (0.008)	0.010 (0.008)	0.004 (0.008)
$\hat{m}_{j,t} / \hat{A}_{j,t}$	0.158^{**} (0.015)	0.131^{**} (0.015)	—	0.127^{**} (0.022)	0.104^{**} (0.022)	—
$\boldsymbol{LIQ_{j,t}}$	—	—	[Fig. 5A]	—	—	[Fig. 5C]
$\Delta\ln C_{j,t}$	—	$-0.029^{\dagger}$ (0.018)	—	—	-0.073^{**} (0.033)	—
Interest cost	-0.005^{**} (0.001)	-0.005^{**} (0.001)	-0.006^{**} (0.001)	-0.008^{**} (0.002)	-0.009^{**} (0.002)	-0.008^{**} (0.002)
Markup	0.016^{**} (0.004)	0.015^{**} (0.004)	0.020^{**} (0.004)	0.020^{**} (0.008)	0.014^{**} (0.008)	0.020^{**} (0.008)
$\Delta\ln m_{j,t}$	—	-0.021^{**} (0.002)	—	—	-0.021^{**} (0.002)	—
Time-varying liquidity effects	No	No	Yes	No	No	Yes
$\overline{R}^2$	0.154	0.161	0.157	0.091	0.098	0.106
N	37,808	37,808	37,808	29,114	29,114	29,114

Notes: The regressions are performed with the S&P 500 data (659 firms in 53 industries) and the non-S&P 500 data (689 firms in 46 industries) for the 1975:4–97:4 period. The dependent variable is $\Delta\ln V_{j,t}$, and the liquidity measure is $\hat{m}_{j,t} / \hat{A}_{j,t}$, defined as the beginning-of-period ratio of liquid assets to total assets. Time-varying liquidity effects ($\boldsymbol{LIQ_{j,t}}$) are captured by a set of year-liquidity dummies whose coefficient estimates are depicted in Figure 5. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 6. Effects of Monetary Policy on Inventory Growth

Independent variable	S&P 500 firms (c′)	S&P 500 firms (g′-1)	S&P 500 firms (g′-2)	Non-S&P 500 firms (c′)	Non-S&P 500 firms (g′-1)	Non-S&P 500 firms (g′-2)
$\Delta\ln V_{j,t-1}$	−0.105** (0.015)	−0.109** (0.015)	−0.111** (0.016)	−0.065** (0.021)	−0.072** (0.021)	−0.074** (0.021)
$\ln (V_{j,t-1}/S_{j,t-1})$	−0.039** (0.002)	−0.036** (0.002)	−0.035** (0.002)	−0.042** (0.004)	−0.039** (0.004)	−0.037** (0.004)
$\Delta\ln S_{j,t}$	−0.035* (0.021)	−0.071** (0.015)	−0.073** (0.015)	0.107** (0.033)	0.031* (0.015)	0.031* (0.015)
$\Delta\ln S_{j,t-1}$	−0.086** (0.016)	−0.087** (0.016)	−0.089** (0.016)	−0.050** (0.008)	−0.049** (0.008)	−0.046** (0.008)
$\Delta\ln S_{j,t-2}$	0.082** (0.011)	0.079** (0.011)	0.076** (0.011)	0.004 (0.008)	0.005 (0.008)	0.005 (0.008)
$\overline{\hat{m}_{j,t} / \hat{A}_{j,t}}$	—	—	0.146** (0.016)	—	—	0.120** (0.022)
$\Delta\ln C_{j,t}$	−0.035** (0.018)	—	—	−0.082** (0.032)	—	—
$\overline{\textit{Interest cost}}$	—	−0.010** (0.001)	−0.006** (0.001)	—	−0.011** (0.002)	−0.007** (0.002)
Markup	—	0.024** (0.004)	0.016** (0.004)	—	0.027** (0.007)	0.021** (0.008)
Policy shocks	[Fig. 6A]	[Fig. 6B]	[Fig. 6C]	[Fig. 6D]	[Fig. 6E]	[Fig. 6F]
Time-varying liquidity effects	No	No	Yes	No	No	Yes
$\bar{R}^2$	0.151	0.153	0.157	0.087	0.089	0.092
N	38,051	38,051	37,881	29,515	29,515	29,245

Notes: The regressions are performed with the S&P 500 data (659 firms in 53 industries) and the non-S&P 500 data (689 firms in 46 industries) for the 1975:4–97:4 period. The dependent variable is $\Delta\ln V_{j,t}$, the liquidity measure is $\hat{m}_{j,t} / \hat{A}_{j,t}$, defined as the beginning-of-period ratio of liquid assets to total assets, and '—' denotes demeaned variable for the cross average. The effects of monetary policy shocks are captured by current and 8 lags of the Federal fund rate change (in fraction) whose coefficient estimates are depicted in Figure 6. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 7. Bond Ratings and Liquidity Effects

Independent variable	S&P 500 firms			Non-S&P 500 firms		
	(c″)	(g″-1)	(g″-2)	(c″)	(g″-1)	(g″-2)
$\Delta\ln V_{j,t-1}$	−0.105** (0.020)	−0.132** (0.022)	−0.132** (0.022)	−0.018** (0.017)	−0.043** (0.019)	−0.044** (0.019)
$\ln(V_{j,t-1}/S_{j,t-1})$	−0.045** (0.006)	−0.040** (0.004)	−0.040** (0.004)	−0.047** (0.004)	−0.041** (0.005)	−0.041** (0.005)
$\Delta\ln S_{j,t}$	−0.031** (0.025)	−0.062** (0.021)	−0.062** (0.021)	0.118** (0.035)	0.043** (0.019)	0.042** (0.019)
$\Delta\ln S_{j,t-1}$	−0.094** (0.021)	−0.091** (0.024)	−0.092** (0.024)	−0.037** (0.010)	−0.035** (0.010)	−0.035** (0.010)
$\Delta\ln S_{j,t-2}$	0.073** (0.020)	0.086** (0.016)	0.085** (0.016)	0.002 (0.010)	0.000 (0.010)	0.000 (0.010)
$\hat{m}_{j,t}/\hat{A}_{j,t}$	0.137** (0.017)	0.158** (0.016)	—	0.130** (0.016)	0.120** (0.024)	—
$\hat{m}_{j,t}/\hat{A}_{j,t}\times Bdum_{j,t}$	−0.009 (0.023)	−0.024 (0.016)	—	0.049 (0.081)	0.026 (0.087)	—
$\hat{m}_{j,t}/\hat{A}_{j,t}\times(1-Rdum_t)\times Bdum_{j,t}$	—	—	0.142** (0.025)	—	—	0.168† (0.093)
$\hat{m}_{j,t}/\hat{A}_{j,t}\times(1-Rdum_t)\times(1-Bdum_{j,t})$	—	—	0.173** (0.022)	—	—	0.136** (0.025)
$\hat{m}_{j,t}/\hat{A}_{j,t}\times Rdum_t\times Bdum_{j,t}$	—	—	0.063 (0.051)	—	—	0.036 (0.166)
$\hat{m}_{j,t}/\hat{A}_{j,t}\times Rdum_t\times(1-Bdum_{j,t})$	—	—	0.051 (0.044)	—	—	−0.013 (0.045)
$\Delta\ln C_{j,t}$	−0.031 (0.020)	—	—	−0.098** (0.034)	—	—
Interest cost	—	−0.005** (0.002)	−0.006** (0.002)	—	−0.008** (0.002)	−0.008** (0.002)
Markup	—	0.003 (0.006)	0.004 (0.006)	—	0.026** (0.008)	0.026** (0.008)
$\bar{R}^2$	0.152	0.159	0.160	0.083	0.087	0.088
N	23,514	21,419	21,419	24,368	20,477	20,477

Notes: The regressions are performed with the S&P 500 data (659 firms in 53 industries) and the non-S&P 500 data (689 firms in 46 industries) for the 1985:1–97:4 period. The dependent variable is $\Delta\ln V_{j,t}$, and the liquidity measure is $\hat{m}_{j,t}/\hat{A}_{j,t}$, defined as the beginning-of-period ratio of liquid assets to total assets. $Rdum_t$ is a dummy for recession periods, which takes the value one 1 for 1990:3–91:4. $Bdum_{j,t}$ is a bond market access dummy that takes the value one if firm j has a S&P senior debt rating (investment grade rating or higher) at time t. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 8. The Effects of Bond Ratings and Cash Flow on Inventory Investment

Independent variable	S&P 500 firms			Non-S&P 500 firms		
	(j)	(k)	(l)	(j)	(k)	(l)
$\Delta\ln V_{j,t-1}$	−0.088** (0.017)	−0.088** (0.017)	−0.089** (0.023)	−0.062** (0.024)	−0.063** (0.024)	−0.041† (0.024)
$\ln(V_{j,t-1}/S_{j,t-1})$	−0.033** (0.003)	−0.037** (0.003)	−0.038** (0.004)	−0.029** (0.004)	−0.029** (0.004)	−0.037** (0.006)
$\Delta\ln S_{j,t}$	−0.094** (0.020)	−0.097** (0.020)	−0.075** (0.029)	0.016 (0.014)	0.015 (0.014)	0.014 (0.014)
$\Delta\ln S_{j,t-1}$	−0.104** (0.023)	−0.105** (0.023)	−0.107** (0.010)	−0.060** (0.010)	−0.060** (0.010)	−0.060** (0.017)
$\Delta\ln S_{j,t-2}$	0.075** (0.015)	0.073** (0.015)	0.093** (0.035)	0.017* (0.008)	0.015† (0.008)	0.008 (0.009)
$Cashflow_{j,t-1}/\hat{A}_{j,t} \times Rdum_{j,t}$	0.381** (0.041)	—	—	−0.300 (0.062)	—	—
$Cashflow_{j,t-1}/\hat{A}_{j,t} \times (1-Rdum_{j,t})$	0.783** (0.130)	—	—	0.635** (0.062)	—	—
$Cashflow_{j,t-1}/\hat{A}_{j,t} \times (1-Rdum_t)\times Bdum_{j,t}$	—	—	0.500* (0.212)	—	—	0.611† (0.333)
$Cashflow_{j,t-1}/\hat{A}_{j,t} \times (1-Rdum_t)\times(1-Bdum_{j,t})$	—	—	0.797** (0.229)	—	—	0.560** (0.170)
$Cashflow_{j,t-1}/\hat{A}_{j,t} \times Rdum_t \times Bdum_{j,t}$	—	—	0.181 (0.233)	—	—	0.247 (0.778)
$Cashflow_{j,t-1}/\hat{A}_{j,t} \times Rdum_t \times (1-Bdum_{j,t})$	—	—	0.548† (0.313)	—	—	−0.243 (0.225)
$CF_{j,t}$	—	[Fig. 7A]	—	—	[Fig. 7B]	—
Interest cost	−0.004* (0.002)	−0.006** (0.002)	−0.007** (0.002)	−0.007** (0.002)	−0.008** (0.002)	−0.006** (0.002)
Markup	0.013** (0.005)	0.019** (0.005)	0.004 (0.006)	0.014† (0.008)	0.014† (0.008)	0.017** (0.006)
$\bar{R}^2$	0.155	0.158	0.154	0.090	0.091	0.088
N	28,647	28,647	17,024	23,789	23,789	15,992

Notes: Regressions (j) and (k) were performed for the 1975:1–97:4 period, and regressions (l) was performed for the 1985:1–97:4 period. The dependent variable is $\Delta\ln V_{j,t}$. $Rdum_t$ is a dummy for recession periods, which takes the value 1 for 1990:3–91:4. $Bdum_{j,t}$ is a bond market access dummy that takes the value one if firm *j* has a S&P senior debt rating (investment grade rating or higher) at time *t*. Time-varying cash flow effects ($CF_{j,t}$) are captured by a set of year-cash flow dummies whose coefficient estimates are depicted in Figure 7. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 9. Annual Panel Regressions

Independent variable	S&P 500 firms (j′)	S&P 500 firms (k′)	S&P 500 firms (l′)	Non-S&P 500 firms (j′)	Non-S&P 500 firms (k′)	Non-S&P 500 firms (l′)
$\Delta\ln\ V_{j,t-1}$	-0.068^{**} (0.018)	-0.068^{**} (0.018)	-0.084^{**} (0.024)	-0.145^{**} (0.025)	-0.145^{**} (0.019)	-0.138^{**} (0.030)
$\ln\ (V_{j,t-1}/S_{j,t-1})$	-0.077^{**} (0.008)	-0.082^{**} (0.008)	-0.083^{**} (0.010)	-0.092^{**} (0.010)	-0.093^{**} (0.005)	-0.092^{**} (0.013)
$\Delta\ln\ S_{j,t}$	0.844^{**} (0.032)	0.842^{**} (0.032)	0.868^{**} (0.041)	0.825^{**} (0.042)	0.828^{**} (0.032)	0.845^{**} (0.050)
$\Delta\ln\ S_{j,t-1}$	0.056^{**} (0.026)	0.048^{**} (0.025)	0.022^{**} (0.032)	0.142^{**} (0.036)	0.144^{**} (0.025)	0.126^{**} (0.045)
$\hat{m}_{j,t}/\hat{A}_{j,t}\times(1-Rdum_{j,t})$	0.298^{**} (0.046)	—	—	0.283^{**} (0.062)	—	—
$\hat{m}_{j,t}/\hat{A}_{j,t}\times Rdum_{j,t}$	0.248^{**} (0.077)	—	—	0.046 (0.078)	—	—
$\hat{m}_{j,t}/\hat{A}_{j,t}\times(1-Rdum_t)\times Bdum_{j,t}$	—	—	$0.120^{\dagger}$ (0.076)	—	—	0.706^{**} (0.230)
$\hat{m}_{j,t}/\hat{A}_{j,t}\times(1-Rdum_t)\times(1-Bdum_{j,t})$	—	—	0.274^{**} (0.071)	—	—	0.244^{**} (0.082)
$\hat{m}_{j,t}/\hat{A}_{j,t}\times Rdum_t\times Bdum_{j,t}$	—	—	0.030 (0.119)	—	—	0.974 (0.694)
$\hat{m}_{j,t}/\hat{A}_{j,t}\times Rdum_t\times(1-Bdum_{j,t})$	—	—	0.128 (0.154)	—	—	0.007 (0.083)
$LIQ_{j,t}$	—	[Fig. A.2A]	—	—	[Fig. A.2B]	—
Interest cost	—	−0.004 (0.004)	−0.005 (0.005)	—	0.000 (0.002)	−0.001 (0.005)
Markup	—	0.008 (0.014)	−0.005 (0.018)	—	−0.018 (0.023)	−0.016 (0.028)
$\bar{R}^2$	0.340	0.352	0.373	0.419	0.421	0.425
N	8,492	8,492	4,443	5,601	5,601	3,485

Notes: Regressions (j′) and (k′) were performed for the 1975–97 period, and regressions (l′) was performed for the 1985–97 period. The dependent variable is $\Delta\ln\ V_{j,t}$, and the liquidity measure is $\hat{m}_{j,t}/\hat{A}_{j,t}$, defined as the beginning-of-period ratio of liquid assets to total assets. $Rdum_t$ is a dummy for recession periods, which takes the value one 1 for 1975, 1981–82, 1990–91. $Bdum_{j,t}$ is a bond market access dummy that takes the value one if firm j has a S&P senior debt rating (investment grade rating or higher) at time t. Time-varying liquidity effects ($LIQ_{j,t}$) are captured by a set of year-liquidity dummies whose coefficient estimates are depicted in Figure A.2. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

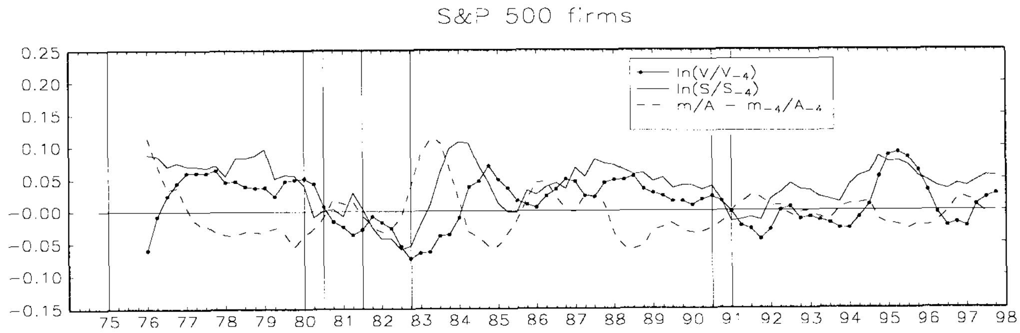
Table 10. Alternative Regressions: in Ratios

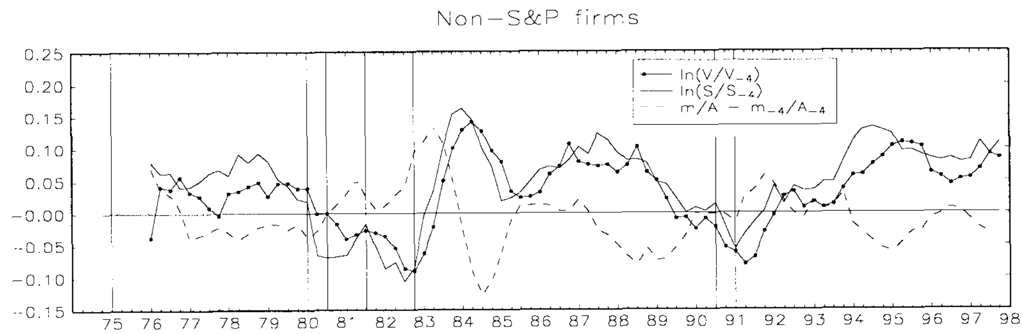
Independent variable	S&P 500 firms			Non-S&P 500 firms		
	(f‴)	(g‴)	(h‴)	(f‴)	(g‴)	(h‴)
$\Delta V^N_{j,t-1} / \hat{A}^N_{j,t-1}$	−0.149** (0.018)	−0.154** (0.018)	−0.155** (0.019)	−0.026* (0.013)	−0.036** (0.013)	−0.036** (0.013)
$V^N_{j,t-1} / S^N_{j,t-1}$	−0.005** (0.001)	−0.005** (0.001)	−0.007** (0.001)	−0.005** (0.001)	−0.006** (0.001)	−0.006** (0.001)
$\Delta S^N_{j,t} / \hat{A}^N_{j,t}$	0.030 (0.024)	0.005 (0.017)	0.003 (0.018)	0.040** (0.017)	0.023† (0.015)	0.023† (0.015)
$\Delta S^N_{j,t-1} / \hat{A}^N_{j,t-1}$	−0.002 (0.008)	−0.002 (0.008)	−0.006 (0.009)	−0.024** (0.004)	−0.022** (0.004)	−0.022** (0.004)
$\Delta S^N_{j,t-2} / \hat{A}^N_{j,t-2}$	0.009† (0.006)	0.011† (0.006)	0.007 (0.006)	0.013* (0.006)	0.013** (0.005)	0.013** (0.005)
$\hat{m}_{j,t} / \hat{A}_{j,t}$	0.030** (0.003)	0.026** (0.003)	—	0.035** (0.005)	0.025** (0.025)	—
$LIQ_{j,t}$	—	—	[Fig. 8A]	—	—	[Fig. 8C]
$\Delta \ln C_{j,t}$	−0.013** (0.004)	—	—	−0.013** (0.004)	—	—
Interest cost	—	−0.002** (0.0003)	−0.002** (0.0003)	—	−0.003** (0.0005)	−0.003** (0.0005)
Markup	—	0.001 (0.0007)	0.002** (0.0007)	—	0.004** (0.0013)	0.004** (0.0015)
Time-varying liquidity effects	No	No	Yes	No	No	Yes
$\bar{R}^2$	0.154	0.161	0.166	0.141	0.141	0.144
N	37,808	37,808	37,808	28,859	28,859	28,859

Notes: The regressions were performed with the S&P 500 data (659 firms in 53 industries) and the non-S&P 500 data (689 firms in 46 industries) for the 1975:4–97:4 period. The dependent variable is $\Delta V^N_{j,t} / \hat{A}^N_{j,t}$, and the liquidity measure is $\hat{m}_{j,t} / \hat{A}_{j,t}$, defined as the beginning-of-period ratio of liquid assets to total assets. Time-varying liquidity effects ($LIQ_{j,t}$) are captured by a set of year-liquidity dummies whose coefficient estimates are depicted in Figure 8. The quarter-industry effects are controlled in all regressions. Standard errors (in parentheses) are computed using White's correction for heteroskedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

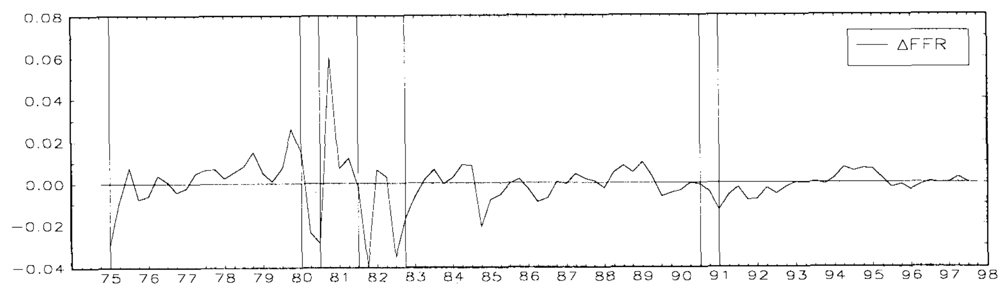
Figure 1. Inventory and Sales Growth, Changes in Liquidity, and the Monetary Policy Stance

A. Cross-section means of the annualized growth of inventory, sales, and annualized change in liquidity



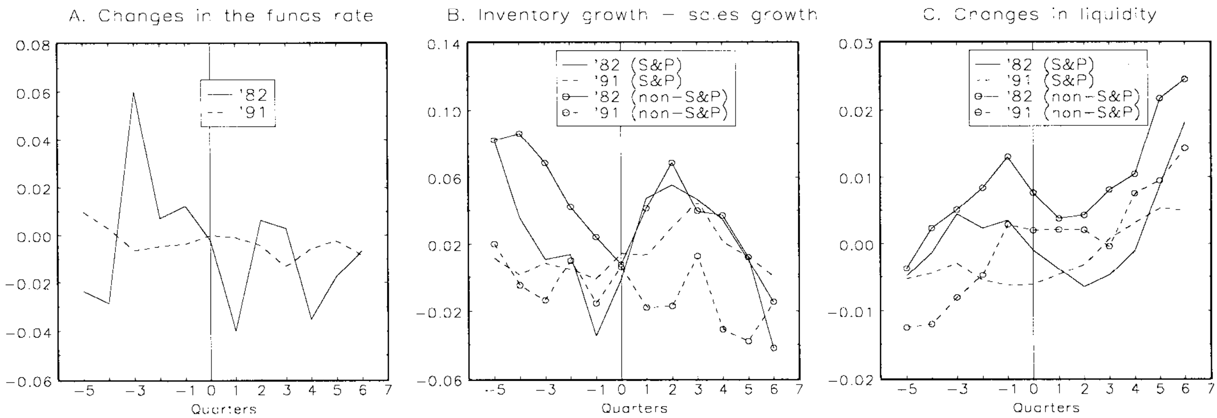


B. The Federal Fund Rate Change as the Monetary Policy Stance



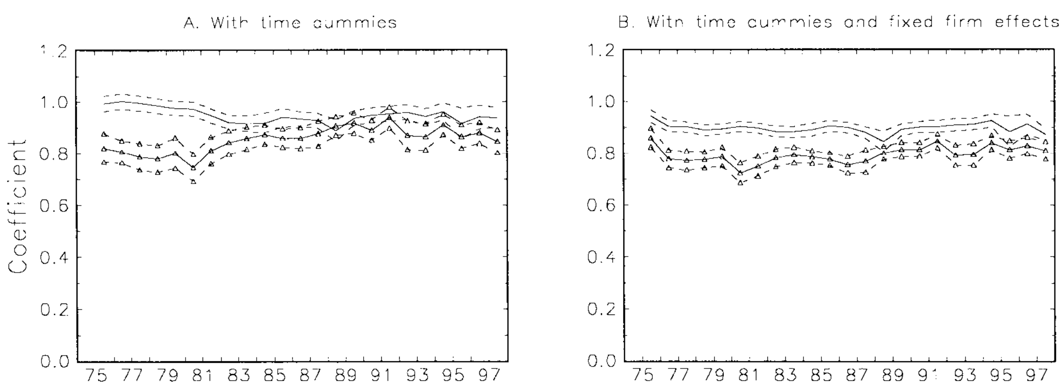
Note: Vertical lines denote National Bureau of Economic Research (NBER) business cycle peaks and troughs. V, S, m, and A denote inventory, sales, liquid assets, and total assets, respectively, all in real terms.

Figure 2. Distributed Movements of Variables Near the Onset of Recessions



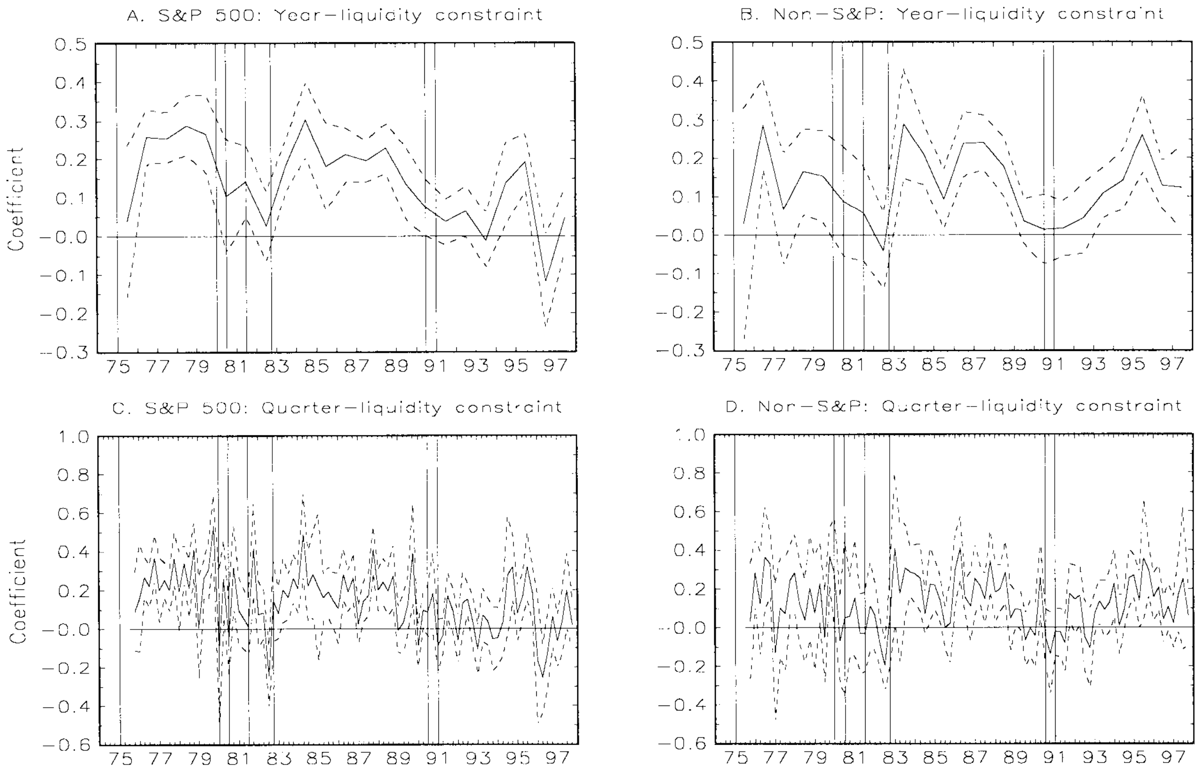
Notes: The '82 and '91 denotes the 1982 recession (1981:4–82:4) and 1991 recession (1990:3–91:4), respectively. The horizontal axes represent the number of quarters before (with a negative sign) and after the onset of a recession. Panel A depicts changes in the Federal funds rate for each recession. Panels B and C depict annualized growth or changes in firm-level variables, relative to nonrecessionary periods. For each recession, the curve for a group of firms is the locus of group mean of j-quarter-ahead variable. The curves without symbols are for S&P firms and those with symbols are for non-S&P firms.

Figure 3. Time-Varying Sales Coefficients in the Inventory-Sales Relation



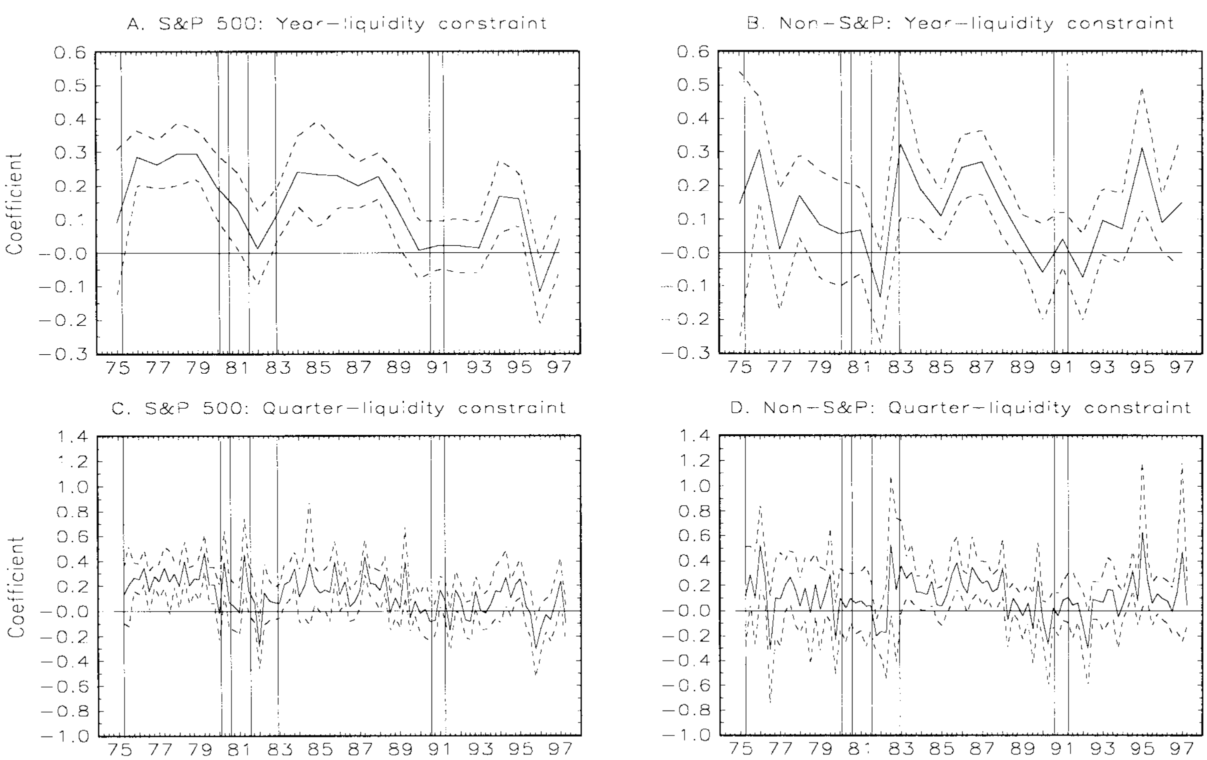
Notes: The lines without symbols are for S&P 500 firms and those with symbols are for non-S&P 500 firms. Dashed lines are 95 percent confidence intervals. Panel A depicts the time-varying coefficients of sales when quarter-year dummies are included in regressions, and panel B depicts those when both quarter-year dummies and fixed-firm effects are included.

Figure 4. Time-Varying Liquidity Coefficients: Baseline Regressions



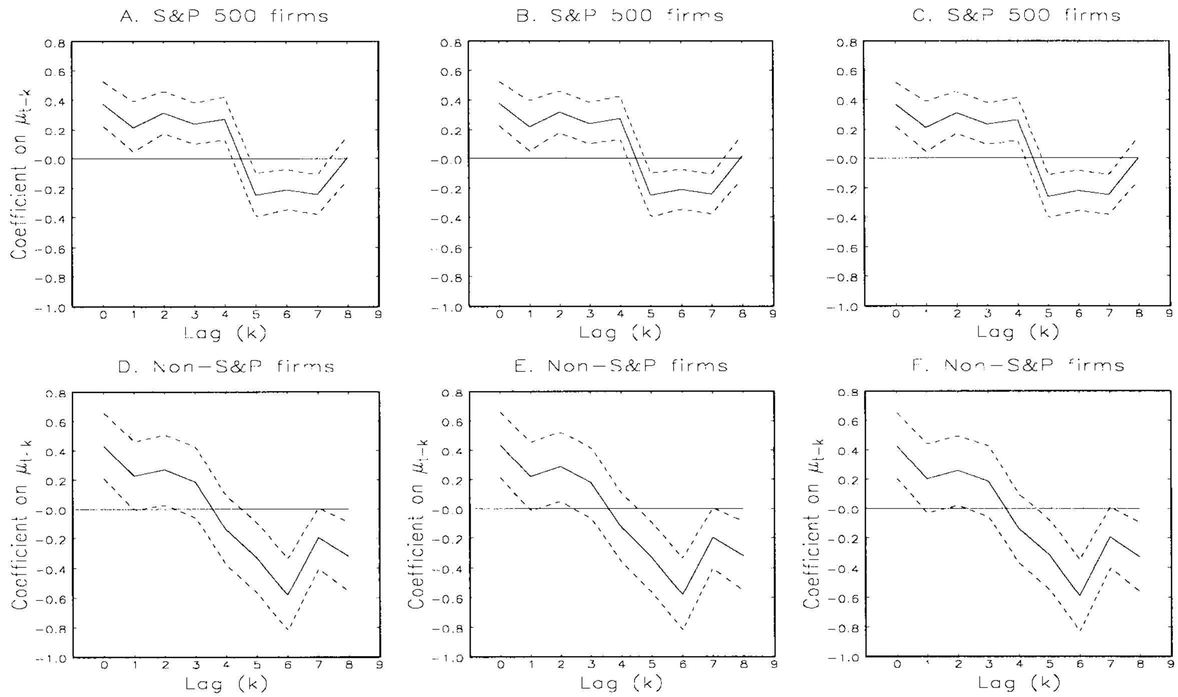
Note: Dashed lines are 95 percent confidence intervals. Vertical lines denote NBER business cycle peaks and troughs.

Figure 5. Time-Varying Liquidity Coefficients: Extended Regressions



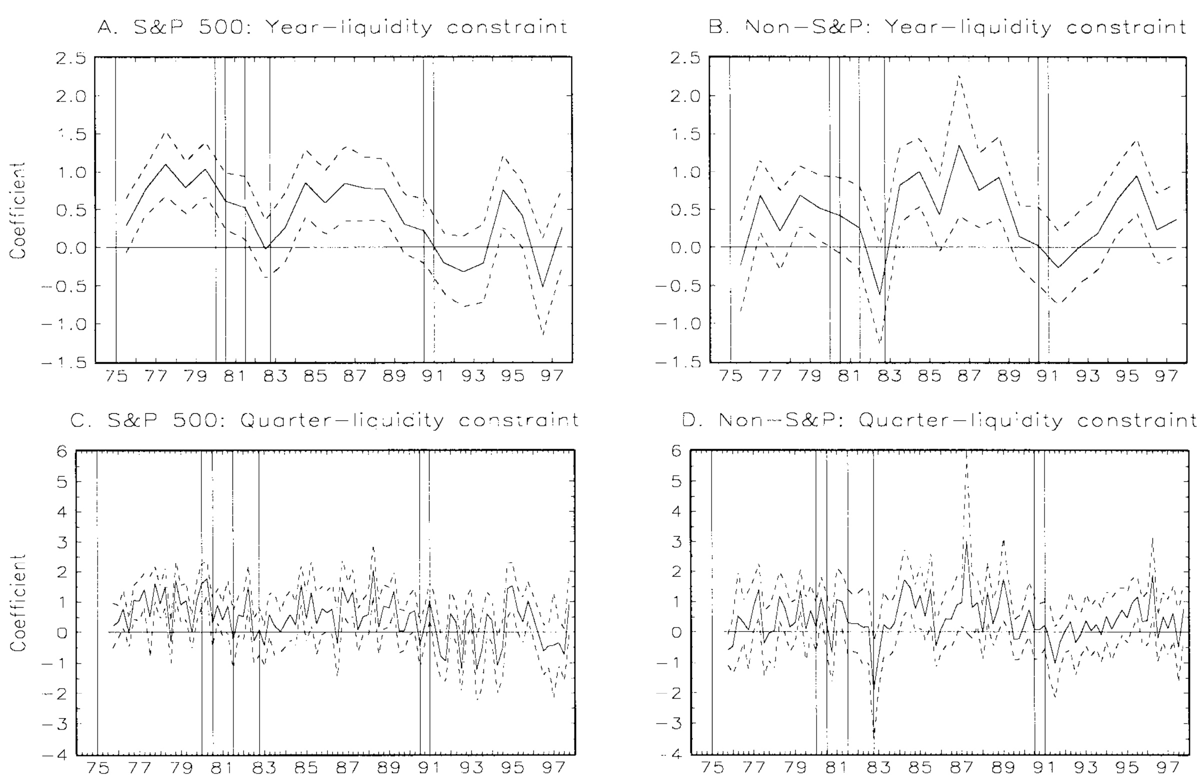
Note: Dashed lines are 95 percent confidence intervals. Vertical lines denote NBER business cycle peaks and troughs.

Figure 6. Effects of Tighter Monetary Policy on Inventory Growth



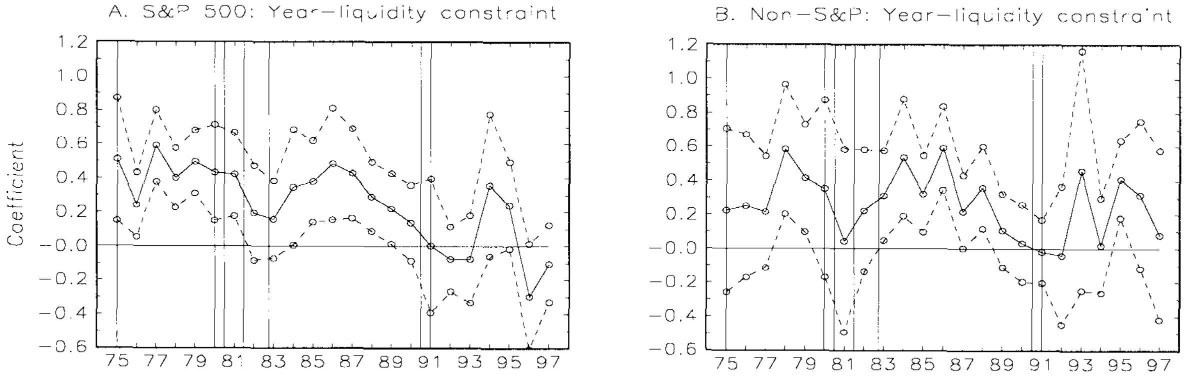
Notes: Coefficient estimates of $\{\Delta FFR_{t-k}\}_{k=0}^{8}$ from the regressions in Table 6. Dashed lines are 95 percent confidence intervals.

Figure 7. Time-Varying Cash Flow Coefficients



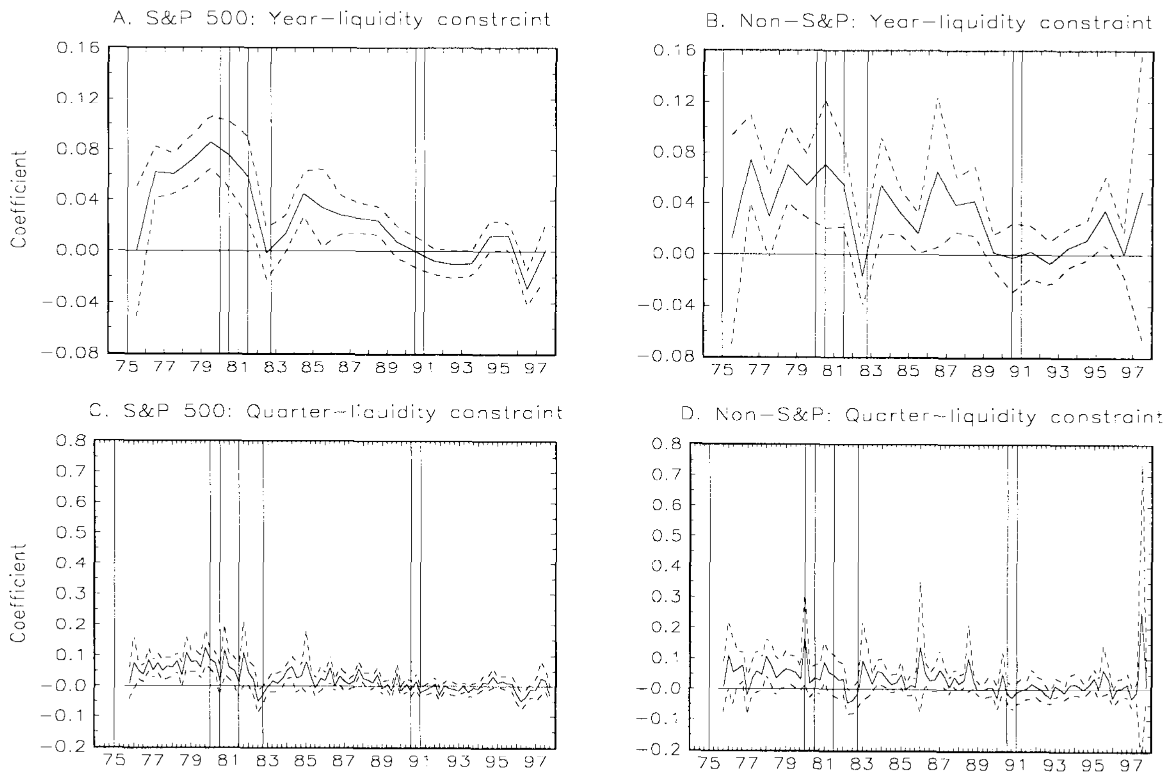
Notes: Dashed lines are 95 percent confidence intervals. Vertical lines denote NBER business cycle peaks and troughs.

Figure 8. Time-Varying Liquidity Coefficients: Annual Data



Notes: Dashed lines with symbols are 95 percent confidence intervals. Vertical lines denote NBER business cycle peaks and troughs.

Figure 9. Alternative Regressions: in Ratios



Notes: Dashed lines are 95 percent confidence intervals. Vertical lines denote NBER business cycle peaks and troughs.

A. The Model of Inventory Behavior

Firms decide capital K_t, labor N_t, outright investment Z_t, indirect investment ($Y_t - S_t^e$), the real balance m_t ($=M_t / P_t$), and other financial assets before they sell produced goods Y_t at the price P_t in period t. The capital stock is rented from consumers as in Ramey (1993), and inventories are traded in the inventory market at the beginning of each period.

A representative firm maximizes the expected discounted real cash flows according to

$$\text{(A1)} \quad Max\ E\left(\sum_{i=0}^{\infty} \beta^i [S_{t+i} - R_{t+i}(B_{t+i} / P_{t+i}) - 0.5(B_{t+i} / P_{t+i})^2 - \rho_{2,t+i-1}(L_{2,t+i-1} / P_{t+i}) - r_{t+i}K_{t+i} - w_{t+i}N_{t+i} - Z_{t+i}] \middle| \mathbf{I}_t \right)$$

subject to

$$\text{(A2)} \quad S_t = D_t(P_t;\xi_t)\{\varphi(V_{t-1} + Z_t) + Y_t\}^{\tau}, \qquad 0 < \varphi < 1,\ 0 < \tau < 1$$

$$\text{(A3)} \quad Y_t = e^{\lambda_t} K_t^{\delta} N^{\gamma} (V_{t-1} + \chi m_t)^{\alpha} (V_{t-1} + Z_t)^{\eta}$$

$$\text{(A4)} \quad V_t = \hat{V}_t + Y_t - S_t = V_{t-1} + Z_t + Y_t - S_t$$

$$\text{(A5)} \quad M_t = L_{2,t} + L_{2,t-1} + B_t .$$

The expectation is conditioned on the information set $\mathbf{I}_t$, which contains past and current variables, except current sales. V_t is the realized inventory, and $\hat{V}_t$ is the beginning-of-period inventory in period t. λ_t is a technology shock. R_t is the nominal market rate for one period from the beginning of period t, $\rho_{2,t}$ is the two-period loan rate, r_t is the real rental rate on K_t, and w_t is the real wage. The real price of inventories is unity. At the end of period t, the firm pays back the one-period CP (B), returns the two-period loans (L_2) borrowed in period t-1, and distributes its profits to the capital owners. The term $0.5\theta(B / P)^2$ is included to reflect that external financing by CP incurs additional costs.

Constraint (A2) describes the dependence of sales on market demand and goods available for sale, as in Bils and Kahn (2000). The function $D_t(P_t;\xi_t)$ reflects that the demand for goods depends on the market price and a stochastic shock. We assume that inventories promote sales as an imperfect substitute for output that is ready to sell ($0 < \varphi < 1$). Consistent with a competitive market that allows for the possibility of stockouts, sales increase with an elasticity of τ with respect to its available stock.

Constraint (A3) specifies a Cobb-Douglas production function in capital, labor, inventories, and the resources available for the accumulation of inventories used as operational capital. An unplanned inventory change due to a sales shock occurring at the end of the period does not affect current output. Constraint (A4) depicts the stock-flow identities for actual and planned inventories. Equation (A5) specifies the balance-sheet identity that the firm obtains money by borrowing the two-period bank loans or by issuing CPs. It is assumed that the firm's profit is always distributed to the shareholders.

Following Choi and Kim (2000), we introduce the banks' the loan rate setting process and the Fed's policy rule. First, we assume that banks provide loans on the basis of a loan commitment contract and that the loan rate adjusts to the market rate movement with inertia. The loan rate process is given by

(A6) $$\rho_{2,t} = h_1\rho_{2,t-1} + h_2(2R_{t-1} - \rho_{2,t-1}),\ \ 0 < h_1, h_2 < 1.$$

This process reconciles the lending view, because it satisfies the condition that banks are unable to insulate completely their lending activities in longer periods from persistent policy shocks.

We account for the notion that Fed's policy stance influences the interest rate. For simplicity, we assume that the market rate is directly affected by the policy stance μ_t

(A7) $$R_t = \overline{R}e^{\mu_t + \vartheta_t},$$

where $\overline{R}$ is a constant, and ϑ_t is a stochastic error caused by nonpolicy factors. The policy stance follows an autoregressive process, $\mu_t = \nu\mu_{t-1} + \xi_t$, where $0 < \nu < 1$ and ξ_t is an independently distributed error. Equation (A7) reconciles the notion of Taylor's (1993) rule that the interest responds to the economywide output gap, inflation, and the lagged interest rate (Clarida, Galí, and Gertler, 1999).

The problem described above is a typical dynamic optimization program with constraints. The first-order condition with respect to inventory investment is given by

(A8) $$\frac{\tau S_t^e}{\varphi\hat{V}_t + Y_t}\left(\varphi + \frac{\eta Y_t}{\hat{V}_t}\right) + \sum_{i=1}^{\infty}\beta^i \frac{\partial S_{t+i}^e}{\partial Z_t} = 1,$$

where $S_t^e = E(S_t \mid \mathbf{I}_t)$, $\hat{V}_t = V_{t-1} + Z_t$, and $\partial S_{t+i}^e / \partial Z_t$ indicates the expected future marginal sales of current outright investment. Condition (A8) indicates that an increase in Z_t has the effect of increasing current output and sales (the first term) and has the same effect for future output and sales (the second term). The second term arises because Z_t will be carried over to the current and future inventories, which in turn affects future sales. Condition (A8) suggests that $\hat{V}_t$ increases with expected sales and that the diminishing marginal expected sales of inventory investment requires the positive dependence of $\hat{V}_t$ on output. Hence, abstracting from the effect of Z_t on the expected future sales stream, it can be described as

(A9) $$\hat{V}_t = \mathrm{V}(\overset{(+)}{S_t^e}, \overset{(+)}{Y_t}, \cdots).$$

Likewise, the first-order conditions with respect to the rental capital and labor input yields $K_t = \mathrm{K}(\overset{(+)}{S_t^e}, \overset{(+)}{Y_t}, \overset{(-)}{\hat{V}_t}; \overset{(-)}{r_t})$ and $N_t = \mathrm{N}(\overset{(+)}{S_t^e}, \overset{(+)}{Y_t}, \overset{(-)}{\hat{V}_t}; \overset{(-)}{w_t})$. Substituting these two relations into equation (A3) yields

$$\text{(A10)} \qquad Y_t = \Psi(\overset{(+)}{S_t^e}, \overset{(+)}{\hat{V}_t}, \overset{(+)}{V_{t-1} + \chi m_t}; \overset{(-)}{r_t}, \overset{(-)}{w_t}, \overset{(+)}{\lambda_t}),$$

where $\partial Y_t / \partial S_t^e > 1$, as implied by equation (A2). Combining equations (A9) and (A10) to eliminate Y_t, we obtain

$$\text{(A11)} \qquad \hat{V}_t = \varsigma(\overset{(+)}{S_t^e}, \overset{(+)}{V_{t-1} + \chi m_t}; \overset{(-)}{r_t}, \overset{(-)}{w_t}, \overset{(+)}{\lambda_t}).$$

The optimal beginning-of-period inventory increases with expected sales, liquid assets available for inventory trade, and technology shock and decreases with input prices: this is rewritten as equation (6).

Solving for the first-order conditions with respect to liquid assets and bank loans and using (A6) and (A7) to eliminate the current and future spread between the loan rate and market rate (with some tedious steps), the demand for liquid assets can be expressed as (see, for details, Choi and Kim, 2000)

$$\text{(A12)} \qquad m_t = \Phi(\overset{(+)}{\partial S_t^e / \partial Y_t}, \overset{(+)}{Y_t}, \overset{(-)}{V_{t-1}}, \overset{(-)}{R_t}, \overset{(+)}{\mu_t}; \mu_{t-1}, \mu_{t-2}, \mu_{t-3}, \cdots).$$

Substituting (A10) and (A11) into (A12) to eliminate Y_t yields a liquid asset demand relation, similar to (A12) except that the liquid asset demand is also affected by cost factors.

B. Construction of Non-S&P 500 Dataset

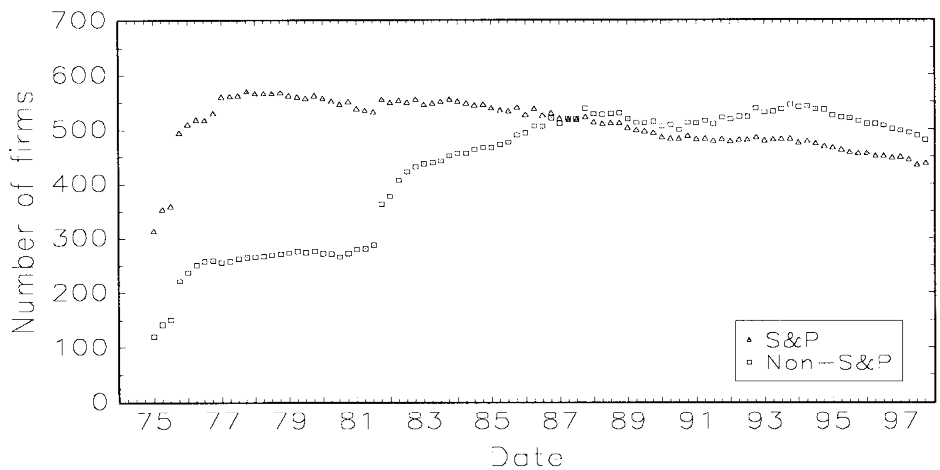
The non-S&P 500 dataset is constructed as follows.

1. We list all the firms from Compustat 1998 that had positive sales for at least one of the three benchmark years 1978, 1987, and 1997, except financial firms and utility firms.
2. For each four-digit SIC industry, we sorted the firms by the *sum* of their real sales in the benchmark years in descending order; we selected twice as many non-S&P firms as the S&P firms. They were among the largest non-S&P firms in the sum of sales meeting the following conditions: their average three-year sales should not exceed either those of the firms that ranked within two-thirds of the S&P firms in the same industry or one half of the largest S&P firm's average sales. (However, when there were only two or three S&P firms in an industry, the average sales were required to be no greater than that of the smallest S&P firm. When there was only one S&P firm, the average sales were required to be no greater than a third of the S&P firm's average sales.)

3. For each quarter, the observation was deleted if the asset size of a firm exceeded the tenth percentile in the asset distribution of S&P firms.
4. Finally, we included in the final sample all firms that reported positive liquid assets, sales, and inventories for more than 12 consecutive quarters, totaling 689 firms.

Since S&P firms tend to have a long listing history, we gave priority to the non-S&P firms with greater *sum* of sales of the three benchmark years. In addition, the second and third steps were applied to exclude firms that were too large at the industry and economywide levels, respectively. Figure A.1 shows the number of included firms by date among the total of 659 S&P firms and 689 non-S&P firms.

Figure A.1. Number of Firms by Date



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