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Monetary Policy and Corporate Liquid Asset Demand

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Abstract

> The views expressed in this Working Paper are those of the author(s) and do not necessarily
> represent those of the IMF or IMF policy. Working Papers describe research in progress by the
> author(s) and are published to elicit comments and to further debate.

In contrast to conventional money demand literature, this paper proposes that monetary
policy affects corporate liquidity demand directly through a separate channel—what we call
"the loan commitment channel." Upon persistent monetary policy shocks, firms make
substitutions between sources of funds for intertemporal liquidity management, taking
advantage of loan commitments and sluggish movements in loan rates. To test this
proposition, we estimate corporate liquidity demand, controlling for firm characteristics,
using U.S. quarterly panel data. The results indicate that when monetary policy is tightened,
S&P 500 firms initially increase their liquid assets before reducing them, whereas non-S&P
firms reduce them more quickly.

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I. INTRODUCTION

Monetary policy actions such as changes in the Federal funds rate and the money supply concern individual firms, because such policy actions affect their cash flows and cost of external funds. To date, the related literature has focused on the transmission mechanism of monetary policy at the aggregate level, which has long been one of the key issues in macro and monetary economics (see Bernanke and Blinder, 1992; Ramey, 1993). There is another important dimension—the behavior of liquid asset holdings at the firm level, which is of special importance in corporate finance (John, 1993; Opler and others, 1999). In this paper, we combine these two dimensions to explain and estimate the direct effects of monetary policy on corporate liquidity demand by using fully disaggregated quarterly panel data.

Conventional money demand literature implies that monetary policy can affect money demand by the economy or firms indirectly through changes in the interest rate. The theory of firms' precautionary demand for money (see Miller and Orr, 1966) posits that monetary policy may affect money demand by influencing cash flow uncertainty. Also, Laidler (1993, p. 187) insightfully points out that considerable turbulence in the conduct of monetary policy may affect the stability of money demand. Nonetheless, the literature suggests no direct link between money demand and monetary policy.

In contrast, the monetary transmission literature has examined how monetary policy affects the supply of bank loans (Bernanke and Blinder, 1988; Kashyap and Stein, 1994) and the liability of firms (Friedman and Kuttner, 1993; Christiano and others, 1996). For example, Christiano and others (1996), using aggregated data on flow of funds, find that upon a tight monetary policy shock, the business sector initially raises net funds. Also, time series tests on the lending channel show that, following tighter monetary policy, bank loans often rise initially and then decline with a lag, roughly coinciding with aggregate spending (Bernanke and Blinder, 1992; Kashyap and Stein, 1994; Bernanke and Gertler, 1995). Bernanke and Blinder (1992) and Morgan (1998) conjecture that this sluggish response of aggregate loans partly reflects the fact that many bank loans are contractual commitments.[2] Morgan provides evidence that loans under commitment contracts are unaffected or even accelerated after tighter policy, whereas those not under commitment contracts are lowered. Choi and Oh (2000) suggest that upon tighter policy, investors increase money holdings in the short run when the money supply is endogenous.

At the firm level, John (1993) argues that firms under stronger financial stress hold more cash than other firms do. Another motive for holding liquid assets, as stated by Opler and others (1999), is to enable firms to continue investing when cash flows are low and outside funds are expensive. These studies suggest that, in tight financial environments, agents strive to keep

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[2]Morgan (1998) indicates that loans under commitment constituted about two-thirds of all commercial loans over the 1975:1–87:2 period using the Federal Reserve Board's Loan Commitment Survey.

liquidity reserves to pursue good investment projects.[3] Such behavior is consistent with the familiar suggestion of market observers: after the economic expansion nears its peak, "as central banks raise interest rates to quell inflation, cash is king" (*The Economist*, April 21–27, 2001). However, few studies have been conducted on the effects of monetary policy on firms' financial decisions.

In a simple model, we incorporate an important feature of the credit view that bank loans and bonds are imperfect substitutes (Bernanke and Blinder, 1988) and that commercial loans can be provided to firms on demand through loan commitments (Morgan, 1998; Holmstrom and Tirole 1998; Kashyap and others 1999). We also introduce inventories as close substitutes for liquid assets, since they are more marketable than other physical assets and are readily reversible (Carpenter and others, 1994), and as a factor of production (Ramey, 1989). We propose that monetary policy affects corporate liquidity demand directly through a separate channel—what we call "the loan commitment channel." Upon persistent monetary policy shocks, firms make substitutions between sources of funds for intertemporal liquidity management, taking advantage of loan commitments and sluggish movements in loan rates. Specifically, since the loan rate often responds to tighter policy more slowly than does the market rate, the spread between the loan rate and the commercial paper (CP) rate initially drops. Expecting higher fund-raising costs in the near future, firms with access to credit lines committed by banks accumulate liquidity reserves by drawing on credit lines on a longer term basis while proportionately reducing the CP issuance. As credit lines are exhausted and the spread begins to rise, firms may temporarily increase their CP issuance, but they eventually reduce net funding of liquidity reserves. Since firms differ in their access to loan commitments and CP issuance, monetary policy has heterogeneous effects on corporate liquid assets.

Guided by the implications of our model, we specify regression equations that focus on the management of liquid assets, on the basis of the identification scheme that policy has contemporaneous impacts on liquidity, but when policy reacts to those variables, it does so with a lag. We estimate panel regressions to determine how corporate liquid assets (defined as cash plus short-term investments) respond to motivating factors, especially monetary policy shocks. The data for the period 1975:1–97:4 are taken from Compustat files for two distinct groups of firms: S&P 500 and non-S&P firms, for comparison purposes. We also examine the implications of firm size or creditworthiness for the heterogeneous effects of monetary policy on liquid assets.

Our empirical analysis indicates the following. First, upon tighter monetary policy, S&P 500 firms initially increase their liquid assets before reducing them, whereas non-S&P firms reduce them more quickly. This finding from firm-level data corroborates the response pattern found for big and small firms' demand for net funds (Christiano and others, 1996). Our finding suggests that firms' responses to tighter policy shocks generate positive policy-induced shocks to money

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[3]From an alternative viewpoint, some studies emphasize a counter-cyclical demand for short-term credit, which results from compensation for declines in firms' cash flows relative to short-term financing requirements (Friedman and Kuttner, 1993; Calomiris and others, 1995; Bernanke and others, 1996).

demand. Tighter policy calls for higher interest rates. Thus, this study helps identify an important source at the firm level for the liquidity puzzle, which states that a positive contemporaneous correlation exists between monetary aggregates and interest rates (Strongin, 1995). Second, liquid asset holdings decrease with inventories, supporting the view of inventories as buffers for internal finance, and variations in liquid assets across firms are explained by firm characteristics including liquidation costs, Tobin's q-ratio, the debt–equity ratio, individual interest costs, and debt ratings.

The paper is organized as follows. Section II provides a background for the monetary policy effect on corporate liquidity demand using a simple model. Section III describes the empirical identification scheme and specifies regressions that are based on our model and extended to control for firm-specific factors. Section IV describes the data and measuring variables. Section V presents estimated results for corporate liquid asset demand, along with some findings from the aggregated data. Section VI provides robustness checks, and Section VII concludes the paper.

II. A CONCEPTUAL BACKGROUND: THE MODEL

The model illustrates in a minimalist fashion that firms change their liquidity holdings through changes in bank loans and CP issues upon monetary policy shocks and that inventories and liquid assets are substitutes in liquidity management. Based on a partial equilibrium approach, we present a simple model that describes firms, banks, and the Federal Reserve ("Fed"), but leaves the rest of the economy unspecified. The model is a modification of Ramey's (1993), which is rooted in Bernanke and Blinder's (1988) formulation of the lending channel. Unlike Ramey, we specify two-period loans that banks provide on demand, inventories in the production function, and the Fed's policy rule reflecting interest rate targeting.

The production function of the representative firm is given by

$$Y_t = f(K_t, N_t, M_t / P_t + \phi V_t, V_t, \lambda_t), \quad 0 < \phi < 1, \tag{1}$$

where Y_t is real output, K_t is the capital stock, N_t is labor, M_t / P_t is real money balances, V_t is the inventory stock, and λ_t is a technology shock. We assume that the capital stock is rented from consumers as in Ramey (1993). Since the firm must pay for some factors of production before receiving revenue, liquidity facilitates the production process. Thus, the *effective* real liquidity, $M_t/P_t + \phi V_t$, where ϕ reflects that inventories are imperfect substitutes for money as buffers for internal finance, is included in the production function.[4] Carpenter and others (1994) argue that because inventories are a large proportion of a firm's assets and readily reversible, a relatively small percentage change in inventories can largely offset changes in cash flow. Also, inventories

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[4] 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 (CIA) constraint is a special case of the use of money in the utility function. We prefer the money-in-production function approach to the CIA constraint approach because the former renders liquidity demand more responsive to interest rates than does the latter.

are a factor of production, as emphasized by Ramey (1989), which means that as the inventory stock falls, it becomes more costly for firms to sacrifice inventories at the margin.

We assume that the firm's profit is always distributed to the shareholders. To reflect that loans have longer maturity than CP, we assume that the maturities of CP and loans are one period and two periods, respectively.[5] Hence, the firm obtains money by borrowing from banks, in the form of two-period bank loans, L_2, or by floating CP, B, in the open market. We also assume that there are no other uses or sources of funds.[6] That is, $M_t = L_{2,t} + L_{2,t-1} + B_t$.

Two features are imposed on the cost of finance. First, according to the lending channel view (see Bernanke and Blinder, 1988; Kashyap and Stein, 1994), bank loans and CP are imperfect substitutes, and external finance by CP incurs additional costs. To reflect this feature, we introduce a quadratic cost function assuming that the additional costs rise with the amount of CP issues. Second, the loan rate is the *effective* rate, consisting of official and implicit costs.[7] The loan rate is assumed to be higher than the market rate but not prohibitively high to ensure that both bank loans and CP are positive, that is, $M_t > B_t > 0$.

The real profit of the representative firm in period t is given by

$$F_t = Y_t - R_t(B_t/P_t) - 0.5\theta(B_t/P_t)^2 - \rho_{2,t-1}(L_{2,t-1}/P_t) - r_t K_t - w_t N_t - V_t, \tag{2}$$

where R_t is the nominal rate of return on the Treasury bills, $\rho_{2,t}$ is the two-period loan rate, r_t is the real rental rate on K, and w_t is the real wage. The real price of inventories is unity, and the cost parameter of issuing CP, θ, is a positive fraction. At the end of period t, the firm pays back the one-period CP with interest, returns the loans borrowed in period $t-1$ with interest, and distributes its profits to the shareholders.

The firm maximizes the expected present value of real profits as follows

$$E_0 \sum_{t=0}^{\infty} \beta^t [Y_t - R_t\{m_t - l_{2,t} - l_{2,t-1}/(1+\pi_t)\} - 0.5\theta\{m_t - l_{2,t} - l_{2,t-1}/(1+\pi_t)\}^2$$
$$- \rho_{2,t-1}l_{2,t-1}/(1+\pi_t) - r_t K_t - w_t N_t - V_t], \tag{3}$$

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[5]Firms may also issue bonds that mature in multiple periods. The expectations hypothesis of the term structure implies a parity between the two-period bond rate and the one-period CP rate. If longer-term bonds are introduced, monetary policy will still affect the spread in the same direction because of imperfect substitutability between loans and CP (or bonds), so that the model's main implications remain unchanged.

[6]For simplicity, we do not take account of equity finance, reflecting, in part, the observation that, for most firms, debt is a more important source of incremental funding than equity (for example, Fazzari and others, 1988), although firms may be able to raise funds by increasing net stocks or by choosing the timing of equity finance. Inventories enhance the firm's flexibility to meet liquidity requirements and are used as inputs of production, but they are not counted as a kind of asset in our model.

[7]Banks' credit-risk management involves a variety of implicit costs. For example, banks may require collateral or compensating balances, impose credit rationing, or require information about the firm's position of asset and liability and business activities. We assume for simplicity that the implicit costs are proportional to bank loans.

where β is the discount factor, π_t is the inflation rate, m_t is the real liquid assets (M_t/P_t), and the balance-sheet identity, $M_t = L_{2,t} + L_{2,t-1} + B_t$, is used to substitute for $b_t (= B_t/P_t)$ in the equation. The firm chooses the optimal levels of liquid assets, period-t loans, CP, inventories, and labor and capital inputs, given their relative prices, interest rates, and period $t-1$ loans.

Among the efficiency conditions, by equating the marginal productivity of real liquidity to its opportunity cost and the marginal benefit of the two-period real loans to its marginal cost, we have the following two conditions:

$$\partial Y_t / \partial m_t = R_t + \theta b_t, \qquad (4)$$

$$R_t + \beta E_t \{ R_{t+1} / (1 + \pi_{t+1}) \} + \theta b_t + \theta \beta E_t \{ b_{t+1} / (1 + \pi_{t+1}) \} = \beta \rho_{2,t} E_t \{ 1 / (1 + \pi_{t+1}) \}. \qquad (5)$$

Define the spread between the two-period loan rate and the market rate over two periods as

$$g_t = \beta \rho_{2,t} E_t \{ 1 / (1 + \pi_{t+1}) \} - R_t - \beta E_t \{ R_{t+1} / (1 + \pi_{t+1}) \} \approx \beta \rho_{2,t} - R_t - \beta E_t (R_{t+1}), \qquad (6)$$

where π_{t+1} is assumed to have a negligible effect on the spread. Taken together, equations (4)–(6) can be used to obtain the liquid asset demand function.[8]

Substituting equation (6) into equation (5) and solving the resulting equation for b_t results in

$$b_t = \theta^{-1} [E_t \sum_{i=1}^{\infty} Q_{t+i} g_{t+i} + g_t], \qquad (7)$$

where $Q_{t+i} = \Pi_{k=1}^{i} (-\beta)^i (1 + \pi_{t+k})^{-1}$ and the transversality condition, $\lim_{T \to \infty} E_t \beta^T B_{t+T} / P_t = 0$, is imposed. We consider a production function given by

$$Y_t = K_t^{\delta} N_t^{\gamma} (m_t + \phi V_t)^{\alpha} V_t^{\eta} e^{\lambda_t}. \qquad (1')$$

Substituting equation (7) and $\partial Y_t / \partial m_t = \alpha Y_t / (m_t + \phi V_t)$ into equation (4), we obtain the demand for liquid assets by the representative firm as the following:

$$m_t = \frac{\alpha Y_t}{R_t + E_t \sum_{i=1}^{\infty} Q_{t+i} g_{t+i} + g_t} - \phi V_t. \qquad (8)$$

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[8]An upper bound for the loan rate exists to ensure that CP issues do not exceed liquid assets. To illustrate, if $\rho_{2,t}$ is above its upper bound, the spread results in a great amount of CP issues sweeping out banks loans, that is, in a corner solution with zero bank loans because of the non-negativity of bank loans.

Corporate liquid asset demand increases with the volume of real output and decreases with the interest rate. Unlike the conventional equation for money demand, this one also depends on the current spread, the expected weighted sum of future spreads, and inventories.

Now we specify the determination of the spread from the interaction between the loan rate set by the banks and the Fed's policy rule. We assume that banks provide loans on the basis of a loan commitment contract.[9] According to Bernanke and Blinder (1988), tighter monetary policy reduces loans and increases the spread. In practice, however, the loan rate often responds to changes in financial markets with a lag (Forbes and Mayne, 1989).[10] To capture that the loan rate adjusts to the market rate movement with inertia, we specify the loan rate process as

$$\rho_{2,t} = h_1 \rho_{2,t-1} + h_2 (2R_{t-1} - \rho_{2,t-1}), \quad 0 < h_1, h_2 < 1. \tag{9}$$

That is, in the short run, banks can insulate their lending activities from shocks to bank reserves by issuing certificates of deposits (CDs) or by paring their net holdings of securities. However, over the long term, they are unable to fully insulate their lending activities from the shocks that persist over several periods.[11]

We account for the Fed's tendency to influence the interest rate (for a survey on the related literature, see Clarida and others, 1999). For simplicity, we assume that the market rate is directly affected by the Fed's policy stance or a policy shock, μ_t,

$$R_t = \bar{R} e^{\mu_t + \vartheta_t}, \tag{10}$$

where $\bar{R}$ is a constant and ϑ_t is a stochastic disturbance caused by nonpolicy factors. The policy stance follows an autoregressive process, $\mu_t = v\mu_{t-1} + \xi_t$, where $0 < v < 1$ and ξ_t is an independently distributed error. Although simple, equation (10) reconciles a general feature that the interest rate can be changed through a liquidity effect (Christiano and Eichenbaum, 1992; Choi, 1999) or through direct control of the funds rate (Taylor, 1993). It can also be considered

[9]Holmstrom and Tirole (1998) explain commitment demand of firms on microfoundations. Banks may also wish to set the optimal commitment of loans as in Kashyap and others (1999). Firms often prefer fixed-rate debt, because it makes their interest payments predictable. According to Kashyap and others, banks can comply with this by combining loan commitment with deposit-taking services, which enables banks to economize on liquid assets as a buffer.

[10] Although most large loans to businesses are tied to the market rate, the majority of loans in the commercial and industrial category are typically priced at some margin over the prime rate serving as the basis for revolving loan commitments (Goldberg, 1982; Brady, 1985). The prime rate has rigidity, which is explained by a kinked demand curve story (Goldberg, 1982) or the retarded dissemination of information (Hadjimichalakis, 1981). The "flight to quality" in bank lending may also explain the perverse movement of the loan rate (Bernanke, 1994).

[11] Banks may fund loans by issuing CDs as a substitute for deposits to a certain extent upon tight monetary policy without significantly raising CD rates. As banks attempt to issue more CDs over periods of tight policy, the increased CD supply eventually pushes CD rates up (Kashyap and Stein, 1994). Alternatively, banks can cope with a higher loan demand by liquidating government bonds on maturity to short-term securities.

as a simplified version of Taylor's rule that allows responses to the economywide output gap, inflation, and the lagged interest rate due to interest rate smoothing (Clarida and others, 1999).

Equations (9) and (10) imply that $\rho_{2,t}$ can be expressed as

$$\rho_{2,t} = 2h_2 \sum_{i=1}^{\infty} (h_1 - h_2)^{i-1} \overline{R} e^{\mu_{t-i} + \vartheta_{t-i}}, \tag{11}$$

where $\lim_{T \to \infty} (h_1 - h_2)^T \rho_{2,t-T} = 0$ is imposed since $|h_1 - h_2| < 1$. The loan rate is a function of lagged shocks only, and the sign of the policy shock effects depends on the lag length and the weight given to the previous loan rate (h_1) and the speed of convergence to a close alignment with the market rate (h_2). Abstracting from the lagged values of an unobservable error, ϑ_t, the spread can be rewritten as: $g_t = g(\mu_t, \mu_{t-1}, \mu_{t-2}, \mu_{t-3}, \cdots)$.[12] If the inflation rate is approximated to a constant, the spread decreases with the current shock and depends on past shocks.

Equations (10) and (11) imply that an increase in μ_t in period t raises R_t and R_{t+1} while leaving ρ_{2t} unchanged. Thus, tighter policy reduces the spread in the short run, providing firms with an incentive to draw on their lines of bank credit.[13] From period $t+1$, the spread will rebound as ρ_{2t} catches up with the market rate (oscillations around the original level can occur if $h_2 > h_1$). In fact, a tight policy shock calls for a brief fall in the spread, which is followed by increases in the spread as shown by Friedman and Kuttner (1993). Equation (8) implies that upon tighter policy the firm increases its liquid assets by increasing its current bank loans while proportionately reducing CP issues. Thus, the demand for liquid assets can be expressed as

$$m_t = \Phi(\overset{(+)}{Y_t}, \overset{(-)}{V_t}, \overset{(-)}{R_t}, \overset{(+)}{\mu_t}; \mu_{t-1}, \mu_{t-2}, \mu_{t-3}, \cdots). \tag{12}$$

In the face of tighter policy, the firm increases the demand for liquid assets contemporaneously.[14] The signs of the effects of lagged policy shocks on the demand for liquid assets, however, depend on the length of lag and the adjustment speed of the loan rate.

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[12] Under the dependence of R_t on R_{t-1} due to the Fed's interest rate smoothing, the spread ends up with the same form. Alternatively, if the policy rule were given by Taylor's rule, the spread would depend on the current and lagged values of inflation along with the output gap. This consideration requires including more variables into the spread function but does not alter the implication of the effect of policy shocks on liquidity demand.

[13] Saidenberg and Strahan (1999) find that big firms chose to draw down funds from backup lines of credit with banks when the spread between loan rates and CP rates fell sharply because of the financial turmoil in the autumn of 1998. They show that lending by big commercial banks rose more than the decline in outstanding CP.

[14] This result is valid even when the loan rate is tied to the current market rate, as long as the loan rate responds to policy shocks less sensitively than does the market rate.

Also, the relation that describes inventories from the first-order conditions is given by

$$\frac{\alpha\phi Y_t}{m_t + \phi V_t} + \frac{\eta Y_t}{V_t} = 1.$$ (13)

Hence, liquid assets are negatively correlated with inventories, while the inventory–output and liquidity–output ratios become steady in the long run.

III. THE EMPIRICAL SPECIFICATIONS

A. The Loan Commitment Channel and Identification Scheme [15]

The availability of bank loan commitments matters in corporate liquid asset demand, as implied by the loan commitment channel. Earlier studies show that loan commitments are less common among riskier, smaller firms. For example, Avery and Berger (1991) find that default rates are lower on loans made under commitments. Morgan (1999) finds that among the smallest 150 firms listed in Compustat, firms without commitments are significantly smaller than those with a commitment. Although firms larger than a certain size tend to have at least one loan commitment as noted by Morgan, the conditions of the loan commitment can differ among firms. Shockley and Thakor (1997) show that firms without bond ratings (or low-quality firms) are more likely to choose loan commitments with usage fees as opposed to commitment without usage fees. Also, most loan commitments contain an escape clause that allows the bank to deny credit if the borrower's financial condition deteriorates. As a result, smaller or low-quality firms benefit less from the liquidity insurance provided by a loan commitment, implying heterogeneous effects of monetary policy on firms with differential access to financing sources.[16]

The loan commitment channel has implications not only for liabilities (source of funds) but also for liquid assets (use of funds).[17] Some empirical findings on the liability side have been presented using time series analysis (see Friedman and Kuttner 1993; Christiano and others 1996), but none has been conducted on the asset side. By estimating corporate liquidity demand, we take a deeper look at firms' asset management upon policy shocks.

Our regression specifications are based on the following identification scheme: policy has contemporaneous and lagged impacts on economic variables, such as interest rates and liquidity but when policy reacts to those variables, it does so with a lag (see Bernanke and Blinder 1992).

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[15]We are grateful to an anonymous referee for inspiring us to elaborate our work along these dimensions.

[16]Earlier studies also suggest that banks prefer lending to big firms (Gertler and Gilchrist, 1994) and that the share of riskier loans drops at the onset of a recession as indicated by the "flight to quality" in bank lending (Lang and Nakamura, 1995; Bernanke and others, 1996).

[17]For simplicity, it was assumed theoretically that bank loans and CP issuance equal liquid assets. In reality, other activities, such as equity financing and capital expenditures, can affect the use and source of funds. Thus, we assume that firms raising funds with loans and CPs put a stable portion of them into their liquid assets.

This scheme implies that the policy stance is weakly exogenous and allows Granger causality from the policy stance to liquidity (for weak exogeneity and Granger causality, see Engle and others, 1983). It is also consistent with policy rule (10), which implies that, given the policy stance, a higher liquidity demand induces an increase in the liquidity supply to keep the interest rate stable, consistent with the credit endogeneity through the loan commitment channel.[18] Therefore, a higher money demand is not expected to cause tighter policy.

B. Regression Models

Using the model as a guide, we specify regression equations for the firm's liquid asset holdings. For firm j at time t, we assume

$$
\begin{aligned}
\ln m_{j,t} = &\, a_s \ln S_{j,t} - a_v \ln \hat{V}_{j,t} - a_R R_t + \Sigma_{k=0}^{3} a_{\mu k} \mu_{t-k} \\
&- a_T T_t + Z\tau + \omega^I + \omega_{1,t}^I + \omega_{2,t}^I + \omega_{3,t}^I + u_{j,t},
\end{aligned}
\tag{14}
$$

where $m_{j,t}$, $S_{j,t}$, and $\hat{V}_{j,t}$ are real liquid assets, real sales measuring firm activity, and the beginning-of-quarter (one-quarter-lagged) real inventory stock in period t, respectively, and μ_{t-k} denotes a policy stance in period $t-k$. T_t denotes a time trend, and $Z\tau$ represents the linear combinations of other exogenous variable effects. The term ω^I is the linear combination of fixed-industry effects, $\{\omega_{p,t}^I\}_{p=1}^{3}$ are seasonal dummies in industry I, and $u_{j,t}$ is a stochastic error. We allow for different seasonal factors in different industries to avoid a moving seasonality due to the time-varying share of some industries whose seasonal pattern differs from others.

An alternative specification is to normalize variables by the beginning-of-quarter total assets of each firm, which helps control for the persistence of variables over time and reduce heteroscedasticity. The demand for liquid assets by firm j is given by

$$
\begin{aligned}
M_{j,t} / \hat{A}_{j,t}^N = &\, b_s(S_{j,t}^N / \hat{A}_{j,t}^N) - b_v(\hat{V}_{j,t}^N / \hat{A}_{j,t}^N) - b_R R_t + \Sigma_{k=0}^{3} b_{\mu k} \mu_{t-k} \\
&- b_T T_t + Z\tau' + \omega^I + \omega_{1,t}^I + \omega_{2,t}^I + \omega_{3,t}^I + \varepsilon_{jt},
\end{aligned}
\tag{15}
$$

where $M_{j,t}$, $S_{j,t}^N$, $\hat{V}_{j,t}^N$, and $\hat{A}_{j,t}^N$ are liquid assets, sales, the beginning-of-quarter inventories, and the beginning-of-quarter total assets, in nominal terms, respectively, and $\varepsilon_{j,t}$ is an error term.

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[18]Also, policy rule (10) implies that the money supply should respond inversely to a positive current aggregate disturbance to the liquidity supply, which otherwise exerts downward pressures on the interest rate. This policy response is also consistent with our identifying assumption that the policy stance is exogenous to liquidity demand.

Monetary policy is assumed to affect all firms symmetrically over time. The time horizon of μ_{t-k} is confined to one year ($k=0,\ldots,3$) to focus on the short-term impacts of policy.[19] The inventory stock is measured by the beginning-of-quarter stock to avoid the simultaneity bias that can occur when the current stock is used. We include the time trend to control for the progress in financial technology and in inventory management, such as just-in-time inventory controls (see Allen, 1995), assuming that the degree of progress is relatively constant across firms.

C. Controlling For Firm-Specific Factors

In the actual data, the liquid assets held by different firms are subject to considerable variations due to differences in the firm attributes. Thus, we can estimate regressions, including a set of additional variables (Z), to control for the firm-specific factors that can have important effects on the adjustment of liquid assets. These variables are as follows:

Research and development (R&D) expenditure—Titman and Wessels (1988) argue that the cost of liquidation is higher for firms that produce unique or specialized products. Such firms will hold more liquid assets than will other firms. As a proxy for the liquidation cost of a firm, the ratio of R&D expenditures to sales is used as in John (1993), Opler and Titman (1994), and Opler and others (1999).

Tobin's q-ratio—Liquidity is often required to finance investments, and firms with more profitable investment opportunities will want to hold more liquidity to fend off the possibility of losing profitable investment opportunities due to liquidity constraint. To take this into account as in Opler and others (1999), we use Tobins' *q*-ratio to reflect the intensity of growth opportunities.

Debt–equity ratio—We attempt to control for the possible effect of agency costs of managerial discretion on liquid asset holdings, since firms may hold excess liquidity to make investments that the capital markets are unwilling to finance. John and John (1993) and Yermack (1995) suggest that debt holders will better monitor firms with higher leverage to reduce managerial discretion and thus agency costs. To account for the effect of firms' agency costs, we add the debt–equity (total liability/stockholder's equity) ratio.

Interest costs of outside funds—The opportunity cost of liquid asset holdings can differ for different firms. Firms with higher interest costs for debts will have stronger incentives to save on cash holdings. To control for the effect of different opportunity costs of liquid asset holdings for different firms, we use the interest expense–total liability ratio. The higher the ratio, the stronger the firm's incentive to save liquidity holdings.

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[19] A correlation between the policy stance and sales or inventories does not pose a problem unless it is extremely high so that it affects the precision of the estimates. Since the policy stance applies to all firms symmetrically and sales and inventories have large variations across firms, the specification here does not pose such a problem.

IV. THE DATA AND MEASURING VARIABLES

We construct two different data sets from Compustat for the period 1975:1–97:4. To link the panel data and time series consistently, the calendar (not fiscal) year date for each firm's data is used. For the main data set, we consider S&P 500 firms from the S&P industrial or transportation index list (Compustat annual item no. 276 = 10 or 49) in any of the three years 1978, 1987, and 1997. We exclude financial firms that may have different motivations in portfolio management (for example, to meet capital requirements) and utility firms that do not report liquid assets. A firm is included in our sample if its liquid assets, sales, and inventories are reported and positive for more than 12 consecutive quarters. After these screenings, we are left with an unbalanced panel that contains 659 firms in 53 industries as indicated by the two-digit standard industrial classification (SIC) code. The alternative data set is comprised of 689 non-S&P firms in 46 industries, which are selected to match the S&P firms closely except that firms in this set are smaller in size (but not too small). Appendix A provides details on the sample.

Liquid assets are defined as cash plus short-term investments (Compustat quarterly item no. 36) as in Opler and others (1999).[20] Figure 1 depicts the cross-section averages of liquid assets, sales, and inventories in real terms from the S&P 500 data set (Panels A and B) and the non-S&P data (Panels C and D). The variables are measured in logs or in ratios (normalized by the beginning-of-quarter total assets). The cross-section average of liquid assets tends to grow less rapidly than that of sales, possibly reflecting the progress of financial technology and more accurate predictions of revenues and payments, both of which enable firms to save liquidity holdings. The stagnant inventory stock may reflect advances in inventory management. An indication of the downward shift in sales and inventories in the early 1980s, which is more pronounced in the non-S&P data, possibly reflects the downsizing of U.S. corporations.

Aggregate time series are from FRED 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. The monetary policy stance in period t is measured by the change in the Federal funds rate, ΔFFR_t, or by the negative value of the mix of nonborrowed reserves and one-period-lagged total reserves, $MNBRX_t$. As shown by Bernanke and Blinder (1992), Strongin (1995), and Christiano and others (1996), both measures are good indicators of the Fed's policy stance. Figure 2A depicts the two quarterly measures of the policy stance and the market rate measured by the three-month Treasury bill rate. A higher value in both measures represents a tighter policy. We use the market rate as a proxy for the opportunity cost of liquidity holdings because the own rates of return on liquid assets are unavailable. Figure 2B depicts the monthly spread between the prime rate (one of the most important indicators of lending rates) and the market rate along with ΔFFR_t. The spread has always been positive and often mirrors ΔFFR_t.

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[20] "Cash" from Compustat's annual files can be a good proxy for M1 held by firms (as described in Mulligan, 1997a,b). This, however, is not available on a quarterly frequency. "Short-term investments" are readily transferable to cash, which include CDs not included in cash, CPs, government securities, marketable securities, money market funds, repurchase agreements, time deposits, Treasury bills, and others.

To show how corporate liquid assets move along with a policy tightening that precedes a recession, Figure 3 depicts distributed movements of policy stance measures and liquidity before and after the onset of the 1982 and 1991 recessions for six quarters. The policy stance becomes tighter as the economy nears the peak and looser as it deepens into recessions (panels A and B). The change in the liquid assets–total assets ratio rises before a recession and then shows a J-shape adjustment after the business cycle peak (panel C). The J-shape adjustment takes place perhaps because liquidity holding is more costly with higher interest rates in the early stage of the recession but becomes less costly with lower interest rates as the recession deepens.

We measure variables to capture firm characteristics as follows. Since the quarterly data of R&D expenditures are not available before 1989, we use the annual data of the R&D ratio. We treat firms with non-available figures as firms with no R&D expenditures as in Opler and others As a proxy for Tobin's q-ratio, we use the market-to-book ratio, [book value of total assets + common stock (market value – book value)]/(book value of total assets), following the finance literature (see Yermack, 1995; Opler and others, 1999). We make an adjustment to the market-to-book ratio for cross-section averages for each period to remove the longer-term trend and cyclical variations. The debt–equity ratio and individual interest cost ratio are also adjusted for the cross-section averages to control for cyclical variations and policy effects. The beginning-of-quarter value of the debt–equity ratio is used to avoid a possible simultaneity between liquid assets and debts.

Table 1a presents the summary statistics of the main variables for the main data set (see Appendix A for the non-S&P data set). On average, liquid assets are about one-fourth of annual sales and 8 percent of total assets. Liquid assets and inventories show more variability than sales do, and they are more closely aligned with assets than with sales as shown by their standard deviations in the ratio (0.104 and 0.139 versus 0.211). Firm-characteristic variables such as the R&D–sales ratio and Tobin's q-ratio are widely dispersed. As shown in Table 1b, the levels of sales, inventories, and liquid assets are highly correlated, consistent with equation (13). In terms of the ratio to total assets, liquid assets are not as closely related to sales as inventories are, implying liquidity management in terms of asset portfolio. Tobin's q-ratio is positively correlated with the R&D–sales ratio possibly because the R&D expenditures reflect to some extent the firm's growth opportunities (Mehran, 1995), whereas it is negatively correlated with the debt–equity ratio.[21] The positive correlation between the individual interest costs and the debt–equity ratio suggests that higher debts render the firm's fund-raising more costly.

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[21] Firms with profitable investment opportunities but higher risk may rely on debt financing, whereas those with good market evaluations may prefer equity financing. The first factor can be outweighed by the second one for the S&P 500 firms as implied by a negative correlation (–0.40) between Tobin's q-ratio and the debt–equity ratio.

V. EMPIRICAL RESULTS

A. Some Findings from Aggregated Time Series

To determine whether our identification scheme is consistent with the actual data, we conduct Granger causality tests using aggregated time series for the 1975:1–97:4 period. One may consider the reverse causality: the monetary policy stance is tightened to mop up excess liquidity contemporaneously as liquid asset demand rises. To deal with this issue, we estimate a policy reaction function under the identifying assumption that policy responds to the aggregated corporate liquidity up to the last quarter, but not to contemporaneous liquidity. We regress ΔFFR on eight lags of ΔFFR, eight lags of the cross-section average of corporate liquid assets scaled by the beginning-of-period total assets, a time trend, and seasonal dummies. The null hypothesis of no Granger causality from corporate liquidity to the policy stance is not rejected by the F-test: the test statistic is $F(8,62) = 0.25$ (p-value $= 0.587$). On the other hand, to test the causality that the policy stance causes corporate liquidity, we estimate a regression that uses the current value of the cross-section average of corporate liquid assets as the dependent variable in place of ΔFFR in the policy reaction function above. The null hypothesis of no Granger causality from the policy stance to corporate liquid assets is strongly rejected: $F(8,62) = 3.90$ (p-value $= 0.001$). Therefore, the causality test results are consistent with our identification scheme.[22]

Next, we attempt to see whether the responses of loans and CPs to tighter monetary policy are consistent with the loan commitment channel explanation.[23] Since the data for CPs and loans are unavailable at the firm level, we use their aggregated time series compiled from FRED. We estimate a monthly vector autoregression (VAR) model that contains five variables in the following order: the change in the Federal funds rate, the change in the three-month CP rate, the spread between the prime rate and the CP rate, the (annualized) growth of loans, and the growth of CPs. The sample period is from 1975:01 to 1987:09, the ending date of which is dictated by the availability of the CPs of nonfinancial companies.[24]

Figure 4 shows the impulse responses of the variables to a positive, 1 percent point shock in the change in the funds rate. The CP rate corresponds closely to the policy shock. The spread response shows an initial fall followed by a hump-shaped curve, consistent with Friedman and Kuttner's (1993) finding. With the initial fall in the spread, the loan growth rises whereas the CP growth shows little change. As the spread rises over the original level after a few months, the loan growth decreases whereas the CP growth increases. These responses are consistent with the loan commitment channel. Upon tighter policy, firms increase loans until the option of

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[22] Using the growth of real liquid assets does not affect the results. Also, the same results for Granger causality are obtained with the non-S&P firm data and with the use of *MNBRX*.

[23] The liability side of liquidity management that reflects corporate financing activities was not included in our study, since most of Compustat items on financings activities are available only from 1987 on a quarterly basis.

[24] The lag length is chosen at nine months. Different lag lengths provide qualitatively similar results, except that the CP growth may not fall initially, depending on the lag length. The initial increase in CP issuance may reflect the need for short-term financing before further rises in the CP rate. Also, the results are robust to different orderings.

committed loans is exhausted.[25] As tighter policy gains momentum and loan rates catch up with market rates, firms start increasing the share of CP issuance to fill up the shortage in their liquidity reserves (see Kashyap and others, 1993). As the financial market distress deepens, eventually, firms reduce external funds.

B. Regressions for Corporate Liquid Asset Demand

An important issue in the literature on corporate money demand is whether economies of scale exist for cash balances.[26] Using the Compustat annual files, Mulligan (1997a) finds that the sales elasticity for cash is 0.83–0.85, implying the presence of economies of scale for cash balances. Using a broader sample of Compustat firms, Mulligan (1997b) finds that the sales elasticity of liquid assets (0.78) is close to the sales elasticity for cash (0.75). In line with these studies, we start with pretest regressions that regress liquid assets on sales alone or on sales and inventories as a substitute for liquid assets for 1975:1–97:4. Log transformation is applied to these variables for the pragmatic virtue of yielding constant elasticities. To control for the financial technology progress, we use time dummies following Mulligan (1997a) or adjust the variables for the cross-section averages. All aggregate variables, associated with cyclical fluctuations and longer-term trends, are swamped in the quarter-year dummies or cross-section averages of the variables. We also estimate regressions by controlling for fixed-firm effects.

Table 2 summarizes the pretest regression results. The estimated sales elasticity is little affected by the choice between the level variables with quarter-year dummies (columns 2–5) and the variables demeaned for the cross-section averages (columns 6–9). The sales elasticity is 0.72–0.76 when the real liquid assets are regressed on sales and 0.79–0.86 when the real liquid assets are regressed on both sales and inventories. Note that regressions controlling for fixed-firm effects have lower estimates for sales elasticity. Standard errors are computed using White's correction for heteroskedastic errors in Table 2 and in what follows.

Now we estimate the baseline regression models. To introduce aggregate variables, we control only for seasonal effects with industry-quarter dummies instead of using quarter-year dummies or demeaning variables by cross-section averages. Fixed-firm effects are still controlled. We consider two alternative specifications: the log and the ratio as in equations (14) and (15). For each specification, we perform two regressions using each of the two policy stance measures, the change in the Federal funds rate, ΔFFR, and the negative value of the mix of nonborrowed reserves and total reserves, $MNBRX$ (see Table 3). In the log specification, regression (a) includes the market rate and the current policy stance, in addition to sales and inventory variables, and regression (b) additionally includes the lagged policy stances and a time

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[25] Eichenbaum (1994) shows that positive, initial responses of bank loans to tighter monetary policy are bigger and more persistent for big firms than for small firms, for which no explicit model has been developed.

[26] Whalen (1965) and Vogel and Maddala (1967) suggest evidence on economies of scale allowing for differences from the asset size of firm, whereas Meltzer (1963) shows that money demand by firms is unit elastic to sales.

trend. The regressors in the ratio specification correspond to those in the log specification except that regression (a), too, includes a time trend to account for a trend in sales and inventory ratios.

Table 3 summarizes the baseline regression results. The log (columns 2–5) and ratio (columns 6–9) specifications provide qualitatively the same implications about monetary policy effects on liquid asset demand. Estimated coefficients have expected signs and are statistically significant, except for lagged values of the policy stance.[27] Most important, tighter policy has a contemporaneous, positive impact on liquid asset holdings. The subsequent impact of tighter policy tends to turn negative in two to three quarters and, in the ratio specification with ΔFFR, becomes marginally significant in three quarters. In all cases, the firms' liquid asset holdings are significantly lowered with the market rate and the time trend.

C. Extended Regressions with Firm-Specific Factors

To incorporate firm-specific factors, regression (c) includes the market rate, current policy stance, and R&D ratio as well as sales and inventories (see Table 4). Regression (d) additionally includes the lagged values of the policy stance, a time trend, and Tobin's q-ratio. Regressions (e) and (f) sequentially add the debt–equity ratio and the individual interest costs, respectively. Again, the regressors in the ratio specification correspond to those in the log specification except that regression (c) includes a time trend. We control for the fixed-industry effects instead of the fixed-firm effects allowing firm-specific factors to capture firm heterogeneity.

Tables 4a and 4b summarize estimated results for the log and ratio specifications, respectively. The results provide the same implications qualitatively as those in the baseline regressions, except that the current policy shock with $MNBRX$ is marginally significant in regression (f). Several additional findings are noteworthy.[28] First, the R&D coefficient is positive and extremely significant (t-value > 40), indicating that firms with high R&D expenditures hold more liquid assets because of higher liquidation costs. Second, the Tobin's q-ratio coefficient is positive and highly significant, implying that firms with high growth opportunities hold more liquid assets to finance future investment. Third, liquid assets are significantly lowered with the debt–equity ratio, implying that the pressure by creditors induces firms to reduce their liquid assets for discretionary purposes. Fourth, the effect of the differential interest costs is negative and strongly significant (t-value < -20). The inclusion of the debt–equity ratio and the individual interest cost reduces somewhat the explanatory power of Tobin's q-ratio. Finally, the sales elasticity becomes close to unity after controlling for firm-specific factors.

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[27]A caveat is that standard errors of coefficients on level variables may have a downward bias due to the persistence of the series over time, although the possible bias will be much reduced in panel data regressions. Nonetheless, the statistical inference for stationary variables measuring the policy stance and firm characteristics in the regression is correct (Park and Phillips, 1989, p.102).

[28]Firms with a high asset-sales ratio can keep more liquid assets in their portfolios, given the wide diversity in the asset–sales ratio in Table 1a. Including the total assets–sales ratio adjusted for the cross-section averages in the log specification strongly supported this conjecture, but left the implications of other regressors unaffected.

D. Firm Size and Access to Financial Markets

We examine whether the effects of monetary policy on corporate liquid asset demand are affected by firm size and access to financial markets (or bond ratings). To show smaller firms' liquid asset demand, Table 5 reports the results of regressions (b) and (f) with the non-S&P data set. The initial impact of tighter policy is positive but insignificant in the log specification, whereas it becomes mixed in the ratio specification. Not surprisingly, non-S&P firms reduce liquid assets quickly upon tighter policy. When the quantity measure of the policy stance (*MNBRX*) is used, liquid asset holdings by non-S&P firms appear to be much less responsive to a policy shock but more responsive to the interest rate. The finding that the positive initial impact is rather weak and fragile for non-S&P firms reflects that the loan commitment channel is less applicable to smaller firms. In addition, liquid asset holdings by non-S&P firms are less sensitive to sales and inventories than those by S&P firms. The sales elasticity is smaller than that for S&P firms, perhaps reflecting that smaller firms hold more liquid assets relative to total assets (see Table A.1 in Appendix A) for non-transactional motives than do big firms. Non-S&P firms are more sensitive to the Tobin's q–ratio, possibly reflecting that smaller firms hold more liquidity to reduce the possibility of losing investment opportunities due to liquidity constraint. Also, non-S&P firms are less sensitive to the R&D ratio but more sensitive to the debt–equity ratio. This may indicate that for smaller firms, R&D expenditures are less important while the agency cost of managerial discretion is more important.

To look at the effects of monetary policy on big and smaller firms over a longer term, we include the current value and 8 lags of ΔFFR_t in regression (f) of the log specification. Figure 5 depicts the current and lagged effects of tighter policy on liquidity demand.[29] For S&P firms, tighter policy has significant positive effects initially and significant negative effects for a year from the third quarter. In contrast, non-S&P firms reduce liquidity demand quickly and to a larger extent. This finding corroborates Christiano and others's (1996) finding from flow of funds data that the initial rise in net funds is concentrated in big firms. When the spread falls with tighter policy, smaller firms may not be able to increase loans much because loan commitments are less available for smaller firms than for big firms. Later on, as the spread increases, loan decreases can be (partly) offset by CP issuances, which are limited to high-quality firms.[30] As a result, smaller firms reduce liquid assets more quickly and to a larger extent than big firms do.

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[29]The price puzzle suggests that tighter policy apparently leads to higher prices unless the model controls for the commodity price index (PCOM) (Sims, 1992; Christiano and others, 1996). Due to this price increase, tighter policy may have a negative effect on real liquid assets in the log specification, whereas the ratio specification is free of the price puzzle. The inclusion of the PCOM/CPI ratio in the log specification to control for this effect leaves the results qualitatively unaffected.

[30]Calomiris and others (1995) report that the CP program was available for about 10 percent out of more than 3,300 U.S. manufacturing firms for 1985:2–92:2. In our sample covering 1985:1–97:4, the share of observations with CP ratings of A3 or higher grade is 54 percent for S&P firms and only 2 percent for non-S&P firms. Thus, most S&P firms can issue CPs, whereas non-S&P firms have limited access to the CP market.

The debt rating reflects the cost of raising funds in financial markets, including banks: for example, various put options linked to debt ratings enable banks to call in loans upon the down grade. High-grade firms will have better access to financial markets and thus have incentives to hold less liquid assets, compared with low-grade firms. To check this view, we define a bond market access dummy, $Bdum_{j,t}$, which takes the value of one if firm j has an S&P senior debt rating of BBB or higher (investment grade ratings) at time t. Low-grade observations are more heavily concentrated in non-S&P firms (53 percent) than in S&P firms (30 percent). We estimate regressions that includes $Bdum_{j,t}$ for the 1985:1–97:4 period, the starting date of which is dictated by the availability of the debt rating from Compustat. This dummy set has a significant negative coefficient, implying that high-grade firms hold less liquid assets than do others.[31]

Further, to see whether the effects of policy shocks depend on the firm's bond rating, we estimate regressions by including policy shocks multiplied by $Bdum_{j,t}$ and $(1-Bdum_{j,t})$ separately. Figure 6 depicts the effects of policy shocks for S&P 500 firms before 1985 when the bond rating data are not available and those for high- and low-grade firms separately for 1985:1–97:4. Tighter policy has a larger initial positive impact and less adverse subsequent impacts for high-grade firms than for low-grade firms.[32] However, tighter policy has less significant impacts on corporate liquid assets than before 1985. Perhaps this is because a better financial safety net became available with financial market developments. For example, liquid and interest-earning assets have increasingly been available to firms for short-term liquidity management. Upon tighter policy, firms are able to take short positions on short-term assets before interest rates rise further, thereby enhancing the overall level of liquidity. Such adjustments in the composition of liquid assets will render liquid assets less sensitive to policy shocks.

E. Spread between the Loan Rate and the Market Rate

As shown in equation (8), liquid asset demand is inversely related to the current spread and expected future spreads. Thus, we attempt to estimate directly the effect of the spreads on liquid asset demand, although the spreads are also affected by financial perturbations other than policy and can be affected differently by policy in different groups of firms. We use the prime rate as a proxy of the loan rate because of the unavailability of the individual firm's loan rate data. Assuming that the spread follows an autoregressive process, the expected future spread can be represented by the current and past spreads. Thus, the current and lagged spreads are included in place of policy shocks in regressions (b) and (f).

Table 6 reports the results with the spread variables for both S&P 500 and non-S&P firms. The estimated coefficients of spreads support the loan commitment channel explanation, and the coefficients of other variables except the market rate are almost identical. For S&P 500 firms, the

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[31]The results are robust to alternative measures of debt rating, including the S&P common stock ranking, the commercial paper rating, and subordinated debt rating. Since the debt rating is correlated highly negatively with the individual interest costs, our extended regressions account somewhat for the debt rating effect.

[32]For non-S&P firms, regardless of bond ratings, the initial and subsequent impacts of monetary policy are much less significant than those before 1985.

spread significantly lowers liquid assets in the first two quarters. For non-S&P firms, the spread has a stronger negative effect in the first quarter than for S&P 500 firms and a significant positive effect in the fourth quarter. An increase in spread can be caused by a sluggish loan rate adjustment upon looser policy or by a higher loan rate due to a decrease in the credit supply: the latter may have a stronger adverse effect on liquid assets for smaller firms through the "flight to quality." Thus, the initial impact can be stronger for non-S&P firms than for S&P firms.

Figure 7 shows the current and lagged effects of an increase in the spread over the longer term. An increase in the spread initially reduces liquid assets of both group of firms but increases significantly liquid assets of non-S&P firms after three to four quarters. The reversal of the initial negative impacts, more pronounced for non-S&P firms, perhaps reflecting liquidity build-ups to compensate for larger initial losses in liquidity reserves.

VI. ROBUSTNESS CHECKS

We question the modeling choices embodied in the regressions and further examine the robustness of our main results. For brevity, only some of the important results from the S&P 500 firm data are reported in Table 7.

More detailed SIC codes—We have accounted for industry-dependent seasonality and fixed-industry effects using quarter-industry dummies by the two-digit SIC codes. We find that the use of three- or four-digit SIC codes does not alter the results of the baseline regressions. Narrow SIC codes and firm-characteristics tend to overlap as many industries have only a few firms. Nonetheless, the use of three-digit SIC codes yielded qualitatively the same results.

Cash dividend payment—Our model assumes that firm profits are returned to consumers in each period. In practice, however, firms may not always return profits in the form of dividends. To account for the effect of a firm's dividend policy on its cash flow and liquidity position, we include a dummy set of cash dividend payment that equals one in the years when a firm pays cash dividends and zero otherwise. Table 7 (columns 2 and 6) shows that the coefficient of the dividend dummy is very significant and negative, implying that paying out dividends lowers the liquidity position of firms. All other coefficient estimates are similar to those in regression (f).

Accounts receivable—There is an increasing tendency for firms to liquidate receivables by factorisation or securitisation, although receivables are typically not as readily marketable as liquid assets.[33] The use of the beginning-of-quarter receivables as a proxy for such assets has little effect on our main results, as shown by regression (h) in Table 7. The negative coefficient of receivables indicates that firms with more receivables tend to hold less liquid assets as they expect future cash flows from them.

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[33] We exclude accounts receivable from liquid assets not only because they have less liquidity than cash and short-term assets but also because they include interfirm transactions that may involve a distribution effect of tighter monetary policy (for example, through reallocation of funds from smaller firms toward bigger firms or vice versa).

Cash-flow uncertainty—A firm with stable cash flows can save cash reserves in meeting the expected cash payments such as interest expenses and wage payments. This prediction is in line with the precautionary money demand literature. As in Opler and others (1999), we compute the cash-flow standard deviation for each firm using all observations available and then measure the industry cash-flow uncertainty by taking an average across the two-digit SIC codes of the firm's cash-flow standard deviations.[34] Controlling for seasonality only by quarter dummies, the cash-flow uncertainty has a significant positive coefficient, while the implications for the other variables are unaffected. Controlling for the quarter-industry effects, which take away the explanatory power of the cash-flow uncertainty, the inclusion of the cash-flow uncertainty has little effects on the results, as shown in Table 7 (regression (i), columns 4 and 8).

Alternative measures of regressors—First, since short-term investments included in our measure of liquidity bear some positive returns, the true opportunity cost of liquidity should be the difference between the market rate, R, and the own rate of return on liquid assets. As a proxy of the latter, we use the own rate of return on broad money, an aggregated measure calculated from each individual asset in M2 and its own rate of return.[35] Using the difference between R and the own rate of return on M2, instead of R itself, provides qualitatively similar results, although it affects to some extent the sensitivity of liquidity demand to the opportunity cost and policy shocks (regression (j) in Table 7). Our results are also qualitatively unaffected when the market rate is measured by the three-month CD rate that may have a close link to the loan rate (Forbes and Mayne, 1989). Second, as an alternative proxy for growth opportunities, we use return on asset defined by net income divided by book value of total assets. This exercise provides qualitatively the same result. Third, if firms have stable sources of funds over a long time, their liquidity position will remain more stable. To check whether the maturity composition of debts affects liquidity demand, we use the long term debt–total debt ratio instead of the debt–equity ratio and the individual interest cost, with which the long-term debt ratio is highly correlated. We find that liquidity demand is significantly lowered with the long-term debt ratio, while the implications of other regressors remain unaffected. Lastly, replacing T_t with the log of the financial capital stock to capture progress in financial technology provides similar results, although the significance of the initial policy impact is lowered to the 5 to 10 percent level.

Sample selections—First, we check to see whether our results are driven by a handful of outlier firms. Omitting observations with extreme values (5 percent of both tails) of the left-hand-side variable changes the coefficients but provides qualitatively the same results. Second, we check whether the bias associated with the duration period is responsible for our findings. The use of alternative consecutive observations of 8 and 30 quarters has little effect on the

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[34] We measure cash flows as income after all expenses but before provisions for dividends and depreciation (Compustat quarterly item no. 5 plus no. 8) deflated by total assets to control for firm heterogeneity due to asset size differences across firms and for the cash flow growth over time.

[35] The explicit own rate of M2 is constructed by weighting interest rates on all individual components of M2 by the lagged ratio of the individual components to M2 for the period 1975:1–96:2, the ending date of which is dictated by the availability of interest rates on individual components of M2 (compiled from FRED).

results. Third, to examine whether credit crunches affect our results, we run regressions, excluding all observations in 1982, 1990–1991, or both. This exercise reduces somewhat the significance of the coefficient of the current policy stance but still indicates that tighter policy does not immediately reduce corporate liquid assets. Finally, with the non-S&P firm data set, a variety of alternative regressions provide qualitatively the same results.

Residual-based approach—To get around the concern about the persistence of some variables in the regressions (see footnote 26), we also take a residual-based approach. We first regress the dependent variable on a set of variables consisting of sales, inventories, market rates, a time trend, and an additional variable, such as receivables or cash uncertainty, in addition to quarter-industry dummies. In the second stage, the estimated residual is regressed on current and lagged policy stances and firm-specific factors, which provides very similar statistical inferences for the monetary policy effects and the firm-specific factors.

VII. CONCLUSION

This paper sheds light on how firms adjust their liquid assets to mitigate monetary policy impacts. It suggests that upon tighter monetary policy, firms increase their liquid assets by increasing bank loans through the committed line of credit—as a form of liquidity insurance—to secure liquidity reserves at low financing costs. Our explanation, based on the loan commitment channel, is supported by the responses of the aggregated bank loans and CP issuance to tighter policy and by the causality test results, which are consistent with our identification scheme.

The loan commitment channel is consistent with the results of our panel data analysis of liquid asset demand for different types of firms. Our finding corroborates previous findings that the initial rise in net funds is concentrated in big firms (Christiano and others, 1996) and that it takes several quarters for tighter policy to limit bank loans (Bernanke and Blinder, 1992; Ramey, 1993).[36] Also, our finding suggests that the firms' responses to tighter policy, accompanied by higher interest rates, generate positive policy-induced shocks to money demand, which helps identify an important source at the firm level for the liquidity puzzle.[37]

The monetary policy effects on corporate liquidity have implications for business fluctuations. Our findings suggest that upon tighter policy firms increase liquidity through lines of credit. Firms with loan commitments can thus be insulated from the effects of tighter policy, as argued by Woodford (1996). Earlier studies suggest that the share of bank loans to low-quality

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[36]Besides, our findings on the effects of cash flow uncertainty, R&D intensity, debt ratings, and individual interest costs suggest that holding liquid assets enables firms to avoid paying external finance premia when urgently raising funds, supporting a precautionary motive in money demand.

[37]Our model illustration is based on a closed economy. If we consider an open economy with a pure floating system in which the monetary authority gains monetary autonomy, the exchange rate will fully adjust to a change in the policy stance, leaving capital flows intact. Under a managed floating system, the effect of capital flows on the credit supply will be sterilized if the monetary authority aims at a monetary tightening. Without such a sterilizing intervention, capital inflows will be added to the reserves of banks upon tighter policy, which enables banks to expand loans upon demand, reinforcing the loan commitment channel.

firms drops at the onset of a recession (flight to quality), and only high-quality firms have the ability to issue CPs upon tighter policy (Calomiris and others, 1995). To reduce vulnerability to finance shocks, smaller firms hold more liquid assets compared with big firms, consistent with our results. These different reactions by different firms to policy imply that not only firm heterogeneity in access to financial markets but also the corresponding financial decisions can contribute to the propagation of monetary shocks, as emphasized in Cooley and Quadrini (1999).

In future research, it will be of interest to examine the effect of monetary policy on households' money holdings, for which the loan commitment channel can be important. The results from such research, together with our findings, can shed light on the money demand behavior of the whole economy. Also, it will be of interest to examine how financial market developments affect liquidity management in response to monetary policy using more detailed data of corporate financial assets and to explore the possibility that liquidity management depends on whether monetary policy is tight or loose, as noted in Choi (1999).

Table 1A. Descriptive Statistics for Main Variables

Variable	N	Mean	Standard deviation	Minimum	1st quarter	Median	3rd quarter	Maximum
$\ln m_{j,t}$	46,699	4.128 [0.000]^a	1.634 [1.626]	−5.990 [−10.321]	3.112 [−1.003]	4.183 [0.052]	5.160 [1.032]	9.539 [5.236]
$\ln S_{j,t}$	46,699	6.106 [0.000]	1.331 [1.320]	−4.853 [−10.834]	5.293 [−0.816]	6.166 [0.060]	6.974 [0.867]	10.394 [4.326]
$\ln V_{j,t}$	45,567	5.318 [0.000]	1.462 [1.461]	−5.870 [−11.094]	4.526 [−0.790]	5.432 [0.116]	6.281 [0.962]	9.401 [3.987]
$M_{j,t}/\hat{A}^N_{j,t}$	45,929	0.077 —	0.104 —	0.000 —	0.017 —	0.042 —	0.100 —	3.698 —
$S^N_{j,t}/\hat{A}^N_{j,t}$	45,929	0.328 —	0.211 —	0.001 —	0.205 —	0.294 —	0.397 —	3.133 —
$V^N_{j,t}/A^N_{j,t}$	44,843	0.183 —	0.139 —	0.000 —	0.069 —	0.161 —	0.265 —	1.154 —
R&D /sales	46,699	0.022 —	0.258 —	0.000 —	0.000 —	0.004 —	0.023 —	54.54 —
Tobin's q	42,501	1.539 [0.004]	0.937 [0.896]	0.245 [−1.422]	1.023 [−0.457]	1.250 [−0.236]	1.707 [0.156]	21.31 [19.40]
Debt /equity ^{b}	45,097	0.194 [−0.001]	0.744 [0.726]	−4.193 [−4.238]	−0.230 [−0.405]	0.185 [0.002]	0.578 [0.379]	8.860 [8.498]
Interest cost ^{b}	41,980	−4.694 [−0.002]	0.676 [0.657]	−13.47 [−8.486]	−4.941 [−0.230]	−4.577 [0.120]	−4.297 [0.380]	−1.489 [3.481]

Notes: Distributions of variables are computed with the S&P 500 data (659 firms in 53 industries) for the 1975:1–97:4 period. The CPI is used to convert all current dollars into 1992 dollars in measuring all real variables.
^{a} Figures in square brackets are statistics of the variable adjusted for cross-section average.
^{b} Debt–equity and interest cost ratios are in logarithms.

Table 1B. Correlation Coefficients between Main Variables

	$M_{j,t}/\hat{A}^N_{j,t}$	$S^N_{j,t}/\hat{A}^N_{j,t}$	$V^N_{j,t}/A^N_{j,t}$	R&D /sales	Tobin's q	Debt /equity	Interest cost	
$\ln m_{j,t}$		0.07 (0.00)	−0.04 (0.00)	0.38 (0.00)	0.36 (0.00)	−0.35 (0.00)	−0.26 (0.00)	$M_{j,t}/\hat{A}^N_{j,t}$
$\ln S_{j,t}$	0.61 (0.00)		0.57 (0.00)	−0.08 (0.00)	0.15 (0.00)	−0.07 (0.00)	−0.20 (0.00)	$S^N_{j,t}/\hat{A}^N_{j,t}$
$\ln V_{j,t}$	0.48 (0.00)	0.84 (0.00)		0.00 (0.40)	0.05 (0.00)	−0.13 (0.00)	−0.10 (0.00)	$V^N_{j,t}/A^N_{j,t}$
R&D /sales	0.02 (0.00)	−0.07 (0.00)	−0.01 (0.02)		0.26 (0.00)	−0.23 (0.00)	0.03 (0.00)	R&D /sales
Tobin's q	0.03 (0.00)	−0.22 (0.00)	−0.22 (0.01)	0.26 (0.00)		−0.40 (0.00)	−0.26 (0.00)	Tobin's q
Debt /equity	0.00 (0.47)	0.24 (0.00)	0.16 (0.00)	−0.23 (0.00)	−0.40 (0.00)		0.37 (0.00)	Debt /equity
Interest cost	−0.14 (0.00)	−0.00 (0.31)	−0.01 (0.09)	−0.03 (0.00)	−0.26 (0.00)	0.37 (0.00)		Interest Cost
	$\ln m_{j,t}$	$\ln S_{j,t}$	$\ln V_{j,t}$	R&D /sales	Tobin's q	Debt /equity	Interest cost	

Notes: Pearson correlation coefficients (*p*-values in parentheses) between variables are computed with the S&P 500 data (659 firms) for the 1975:1–97:4 period. Figures for the log specification are in the lower triangle and those for the ratio specification are in the upper triangle. Debt–equity and interest cost ratios are in logarithms and adjusted for cross-section averages.

Table 2. Pretest Regressions for Liquid Asset Demand

Independent Variable	Dependent variable: $\ln m_{j,t}$							
	Level				Deviation from cross-section average			
$\ln S_{j,t}$	0.755** (0.005)	0.719** (0.012)	0.863** (0.009)	0.788** (0.023)	0.754** (0.005)	0.713** (0.012)	0.861** (0.009)	0.785** (0.023)
$\ln \hat{V}_{j,t}$	–	–	-0.100** (0.008)	-0.105** (0.017)	–	–	-0.099** (0.008)	-0.108** (0.017)
Quarter-year effects	Yes	Yes	Yes	Yes	No	No	No	No
Fixed-firm effects	No	Yes	No	Yes	No	Yes	No	Yes
$\bar{R}^2$	0.381	0.381	0.382	0.382	0.376	0.376	0.377	0.377
N	46,698	46,698	44,717	44,717	46,698	46,698	44,717	44,717

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

Table 3. Baseline Regressions for Corporate Liquid Asset Demand

Independent variable	Dependent variable: $\ln m_{j,t}$				Dependent variable: $M_{j,t}/\hat{A}^N_{j,t}$			
	ΔFFR_t (a)	(b)	$MNBRX_t$ (a)	(b)	ΔFFR_t (a)	(b)	$MNBRX_t$ (a)	(b)
$\ln S_{j,t}$	0.694** (0.019)	0.794** (0.024)	0.696** (0.019)	0.796** (0.024)	—	—	—	—
$\ln \hat{V}_{j,t}$	-0.056** (0.015)	-0.112** (0.017)	-0.056** (0.015)	-0.113** (0.017)	—	—	—	—
$S^N_{j,t}/\hat{A}^N_{j,t}$	—	—	—	—	0.107** (0.008)	0.107** (0.008)	0.108** (0.008)	0.108** (0.008)
$\hat{V}^N_{j,t}/\hat{A}^N_{j,t}$	—	—	—	—	-0.328** (0.011)	-0.327** (0.011)	-0.327** (0.011)	-0.327** (0.011)
R_t	-1.793** (0.161)	-3.240** (0.179)	-2.234** (0.198)	-3.332** (0.224)	-0.149** (0.011)	-0.145** (0.012)	-0.168** (0.014)	-0.153** (0.016)
μ_t	1.701** (0.361)	1.681** (0.372)	0.650** (0.134)	0.594** (0.172)	0.096** (0.025)	0.093** (0.026)	0.030** (0.013)	0.035* (0.016)
μ_{t-1}	—	0.799* (0.377)	—	-0.030 (0.206)	—	0.019 (0.025)	—	-0.007 (0.017)
μ_{t-2}	—	-0.000 (0.357)	—	-0.266 (0.214)	—	-0.017 (0.025)	—	-0.002 (0.015)
μ_{t-3}	—	-0.544 (0.359)	—	-0.086 (0.154)	—	-0.052* (0.025)	—	0.000 (0.012)
T_t	—	-0.004** (0.0002)	—	-0.004** (0.0002)	-7.0×10^{-4}** (1.8×10^{-5})	-7.0×10^{-4}** (1.8×10^{-5})	-7.0×10^{-4}** (1.8×10^{-5})	-7.0×10^{-4}** (1.8×10^{-5})
$\bar{R}^2$	0.485	0.487	0.485	0.487	0.183	0.183	0.184	0.184
N	44,717	44,717	44,717	44,717	44,710	44,710	44,710	44,710

Notes: The regressions were performed with the S&P 500 data (659 firms) for the 1975:1–97:4 period. The market rate (R_t) and Federal funds rate (FFR_t) are fractions (annual percentage/100). All regressions include both the quarter-industry effects and fixed firm effects. $\bar{R}^2$ excludes variance explained by the fixed-firm effects. Standard errors (in parentheses) are computed using White's correction for heteroscedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 4A. Extended Regressions for Corporate Liquid Asset Demand: Log of Level

Independent variable	Dependent variable: $\ln m_{j,t}$							
	ΔFFR_t				$MNBRX_t$			
	(c)	(d)	(e)	(f)	(c)	(d)	(e)	(f)
$\ln S_{j,t}$	0.914** (0.013)	0.958** (0.014)	0.995** (0.014)	0.968** (0.014)	0.915** (0.013)ª	0.959** (0.014)	0.994** (0.014)	0.969** (0.014)
$\ln \hat{V}_{j,t}$	−0.105** (0.011)	−0.101** (0.012)	−0.113** (0.014)	−0.087** (0.013)	−0.106** (0.011)	−0.101** (0.012)	−0.112** (0.013)	−0.087** (0.013)
R_t	−1.215** (0.193)	−3.579** (0.222)	−3.613** (0.220)	−3.764** (0.230)	−1.666** (0.243)	−3.665** (0.289)	−3.684** (0.286)	−3.680** (0.300)
μ_t	1.446** (0.436)	1.418** (0.457)	1.392** (0.452)	1.439** (0.470)	0.630** (0.174)	0.487* (0.227)	0.472* (0.225)	0.401 † (0.241)
μ_{t-1}	—	0.441 (0.477)	0.378 (0.473)	0.692 (0.493)	—	−0.021 (0.271)	−0.023 (0.268)	0.073 (0.287)
μ_{t-2}	—	−0.202 (0.467)	−0.256 (0.462)	−0.048 (0.480)	—	−0.317 (0.282)	−0.334 (0.279)	−0.447 (0.299)
μ_{t-3}	—	−0.790 † (0.468)	−0.833 † (0.462)	−0.406 (0.480)	—	−0.055 (0.202)	−0.060 (0.200)	−0.059 (0.213)
T_t	—	−0.005** (0.0002)	−0.005** (0.0002)	−0.006** (0.0003)	—	−0.005** (0.0002)	−0.005** (0.0002)	−0.006** (0.0003)
$R\&D$	9.157** (0.207)	8.666** (0.213)	8.038** (0.198)	8.411** (0.228)	9.150** (0.207)	8.665** (0.213)	8.038** (0.198)	8.403** (0.228)
Tobin's q	—	0.158** (0.008)	0.102** (0.008)	0.054** (0.010)	—	0.158** (0.008)	0.102** (0.008)	0.055** (0.010)
Debt-equity	—	—	−0.274** (0.011)	−0.133** (0.013)	—	—	−0.274** (0.011)	−0.133** (0.013)
Interest cost	—	—	—	−0.254** (0.012)	—	—	—	−0.254** (0.012)
$\bar{R}^2$	0.513	0.535	0.544	0.551	0.513	0.535	0.543	0.551
N	44,717	40,838	40,780	36,635	44,717	40,838	40,780	36,635

Notes: The regressions were performed with the S&P 500 data (659 firms) for the 1975:1–97:4 period. The market rate (R_t) and Federal funds rate (FFR_t) are fractions (annual percentage/100). All regressions include the quarter-industry effects. Standard errors (in parentheses) are computed using White's correction for heteroscedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 4B. Extended Regressions for Corporate Liquid Asset Demand: Ratio

Independent variable	Dependent variable: $M_{j,t}/\hat{A}^N_{j,t}$							
	ΔFFR_t				$MNBRX_t$			
	(c)	(d)	(e)	(f)	(c)	(d)	(e)	(f)
$S^N_{j,t}/\hat{A}^N_{j,t}$	0.132** (0.006)	0.086** (0.005)	0.083** (0.005)	0.054** (0.005)	0.132** (0.006)	0.086** (0.005)	0.083** (0.005)	0.056** (0.005)
$\hat{V}^N_{j,t}/\hat{A}^N_{j,t}$	−0.222** (0.007)	−0.171** (0.007)	−0.195** (0.007)	−0.160** (0.006)	−0.222** (0.007)	−0.171** (0.007)	−0.195** (0.007)	−0.152** (0.006)
R_t	−0.169** (0.014)	−0.167** (0.015)	−0.172** (0.015)	−0.141** (0.013)	−0.189** (0.018)	−0.166** (0.019)	−0.168** (0.019)	−0.150** (0.018)
μ_t	0.101** (0.031)	0.087** (0.030)	0.092** (0.029)	0.082** (0.027)	0.032** (0.016)	0.027** (0.015)	0.027** (0.015)	0.024† (0.015)
μ_{t-1}	−−	0.014 (0.031)	0.015 (0.030)	0.051† (0.027)	−−	−0.003 (0.021)	−0.005 (0.020)	0.004 (0.021)
μ_{t-2}	−−	−0.013 (0.031)	−0.014 (0.031)	0.029 (0.027)	−−	−0.022 (0.020)	−0.024 (0.019)	−0.014 (0.019)
μ_{t-3}	−−	−0.074* (0.033)	−0.072* (0.032)	−0.014 (0.027)	−−	−0.009 (0.014)	−0.010 (0.014)	−0.018† (0.013)
T_t	−4.5×10⁻⁴** (1.7×10⁻⁵)	−4.0×10⁻⁴** (1.7×10⁻⁵)	−4.2×10⁻⁴** (1.7×10⁻⁵)	−4.4×10⁻⁴** (1.6×10⁻⁵)	−4.5×10⁻⁴** (1.7×10⁻⁵)	−4.0×10⁻⁴** (1.7×10⁻⁵)	−4.3×10⁻⁴** (1.7×10⁻⁵)	−4.3×10⁻⁴** (1.6×10⁻⁵)
$R\&D$	0.962** (0.027)	0.729** (0.027)	0.646** (0.026)	0.656** (0.029)	0.961** (0.027)	0.730** (0.027)	0.647** (0.026)	0.630** (0.029)
Tobin's q	−−	0.036** (0.001)	0.029** (0.001)	0.017** (0.001)	−−	0.036** (0.001)	0.029** (0.001)	0.020** (0.001)
Debt-equity	−−	−−	−0.032** (0.001)	−0.010** (0.001)	−−	−−	−0.032** (0.001)	−0.017** (0.001)
Interest cost	−−	−−	−−	−0.013** (0.001)	−−	−−	−−	−0.019** (0.001)
$\bar{R}^2$	0.263	0.354	0.386	0.318	0.263	0.354	0.386	0.317
N	44,710	40,833	40,780	36,635	44,710	40,833	40,780	36,635

Notes: The regressions were performed with the S&P 500 data (659 firms) for the 1975:1–97:4 data. The market rate (R_t) and Federal funds rate (FFR_t) are fractions (annual percentage/100). All regressions include the quarter-industry effects. Standard errors (in parentheses) are computed using White's correction for heteroscedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

Table 5. Regressions with the Non-S&P Firm Data Set

Independent variable	Dependent variable: $\ln m_{j,t}$				Dependent variable: $M_{j,t} / \hat{A}_{j,t}^{N}$			
	ΔFFR_t		$MNBRX_t$		ΔFFR_t		$MNBRX_t$	
	(b)	(f)	(b)	(f)	(b)	(f)	(b)	(f)
$\ln S_{j,t}$	0.588** (0.021)	0.857** (0.017)	0.580** (0.021)	0.851** (0.017)	––	––	––	––
$\ln \hat{V}_{j,t}$	–0.023 (0.016)	–0.066** (0.014)	–0.022 (0.016)	–0.066** (0.014)	––	––	––	––
$S_{j,t}^{N} / \hat{A}_{j,t}^{N}$	––	––	––	––	0.025** (0.005)	–0.003 (0.004)	0.023** (0.005)	–0.004 (0.004)
$\hat{V}_{j,t}^{N} / \hat{A}_{j,t}^{N}$	––	––	––	––	–0.343** (0.011)	–0.215** (0.006)	–0.344** (0.011)	–0.216** (0.006)
R_t	–1.944** (0.271)	–2.257** (0.347)	–2.877** (0.339)	–3.539** (0.448)	–0.055** (0.021)	–0.084** (0.023)	–0.192** (0.026)	–0.227** (0.029)
μ_t	0.439 (0.568)	0.350 (0.720)	0.305 (0.236)	0.413 (0.340)	–0.081[†] (0.045)	–0.024 (0.049)	0.037[†] (0.023)	0.051* (0.023)
μ_{t-1}	–1.628** (0.566)	–2.287* (0.720)	0.203 (0.282)	0.232 (0.401)	–0.250** (0.044)	–0.210** (0.048)	0.015 (0.024)	0.006 (0.028)
μ_{t-2}	–2.074** (0.561)	–2.543* (0.721)	–0.337 (0.287)	–0.277 (0.413)	–0.262** (0.049)	–0.216** (0.050)	–0.036 (0.024)	–0.027 (0.028)
μ_{t-3}	–3.316** (0.561)	–3.769** (0.718)	0.156 (0.214)	0.181 (0.309)	–0.311** (0.043)	–0.315** (0.050)	0.050** (0.019)	0.045[†] (0.024)
T_t	–0.001** (0.0004)	–0.002** (0.0004)	–0.002** (0.0003)	–0.003** (0.0004)	-5.9×10^{-4}** (2.6×10^{-5})	-1.4×10^{-4}** (2.5×10^{-5})	-2.3×10^{-4}** (2.7×10^{-5})	-1.7×10^{-4}** (2.5×10^{-5})
R&D	––	1.118** (0.303)	––	1.118** (0.304)	––	0.053** (0.027)	––	0.053** (0.027)
Tobin's q	––	0.182** (0.013)	––	0.181** (0.013)	––	0.025** (0.001)	––	0.025** (0.001)
Debt-equity	––	–0.329** (0.013)	––	–0.328** (0.013)	––	–0.024** (0.001)	––	–0.024** (0.001)
Interest cost	––	–0.274** (0.013)	––	–0.274** (0.013)	––	–0.017** (0.001)	––	–0.017** (0.001)
Fixed-firm effects	Yes	No	Yes	No	Yes	No	Yes	No
$\bar{R}^2$	0.255	0.346	0.254	0.345	0.143	0.240	0.142	0.238
N	36,295	28,454	36,295	28,454	37,125	28,454	37,125	28,454

Notes: The regressions were performed with the non-S&P 500 data (659 firms) for the 1975:1–97:4 period. The market rate (R_t) and Federal funds rate (FFR_t) are fractions (annual percentage/100). All regressions include the quarter-industry effects. R^2 excludes variance explained by the fixed-firm effects. Standard errors (in parentheses) are computed using White's correction for heteroscedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and [†] indicates significance at the 10% level.

Table 6. Regressions with Spread Variables

Independent variable	S&P 500 firms				Non-S&P firms			
	$\ln m_{j,t}$		$M_{j,t}/\hat{A}^N_{j,t}$		$\ln m_{j,t}$		$M_{j,t}/\hat{A}^N_{j,t}$	
	(b′)	(f′)	(b′)	(f′)	(b′)	(f′)	(b′)	(f′)
$\ln S_{j,t}$	0.791** (0.024)	0.966** (0.014)	0.108** (0.014)	0.056** (0.005)	0.584** (0.021)[a]	0.853** (0.017)	--	--
$\ln \hat{V}_{j,t}$	−0.108 (0.017)	−0.084** (0.013)	−0.324** (0.011)	−0.151** (0.006)	−0.022 (0.016)	−0.065** (0.014)	--	--
$S^N_{j,t}/\hat{A}^N_{j,t}$	--	--	--	--	--	--	0.024** (0.005)	−0.004 (0.004)
$\hat{V}^N_{j,t}/\hat{A}^N_{j,t}$	--	--	--	--	--	--	−0.343** (0.011)	−0.215** (0.006)
R_t	−1.583** (0.215)	−2.337** (0.282)	−0.078** (0.016)	−0.074** (0.017)	−2.226** (0.271)	−2.802** (0.420)	−0.121** (0.026)	−0.090** (0.028)
g_t	−4.185** (0.693)	−3.236** (0.886)	−0.242** (0.047)	−0.178** (0.075)	−6.518** (0.075)	−6.540** (1.315)	−0.545** (0.075)	−0.596** (0.084)
g_{t-1}	−2.827** (0.656)	−2.884** (0.849)	−0.146** (0.043)	−0.136** (0.080)	−1.096 (1.038)	−1.317 (1.275)	−0.091 (0.080)	−0.197 (0.086)
g_{t-2}	−1.027 (0.673)	−0.507 (0.865)	0.012 (0.049)	−0.042 (0.098)	1.017 (1.041)	1.517 (1.306)	0.210* (0.098)	0.110 (0.093)
g_{t-3}	0.242 (0.623)	−0.211 (0.819)	0.058 (0.045)	−0.028 (0.074)	6.304** (0.937)	6.501** (1.205)	0.448** (0.074)	0.440** (0.085)
T_t	−0.003** (0.0002)	−0.004** (0.0003)	-6.4×10^{-4}** (2.0×10^{-5})	-3.6×10^{-4}** (1.6×10^{-5})	−0.001** (0.0004)	−0.003** (0.0004)	-6.3×10^{-4}** (3.3×10^{-5})	-1.1×10^{-4}** (3.1×10^{-5})
R&D	--	8.386** (0.228)	--	0.629** (0.029)	--	1.118** (0.303)	--	0.053** (0.027)
Tobin's q	--	0.055** (0.010)	--	0.020** (0.001)	--	0.182** (0.013)	--	0.024** (0.001)
Debt-equity	--	−0.132** (0.012)	--	−0.017** (0.001)	--	−0.328** (0.013)	--	−0.024** (0.001)
Interest cost	--	−0.254** (0.012)	--	−0.019** (0.001)	--	−0.274** (0.013)	--	−0.017** (0.001)
Fixed-firm effects	Yes	No	Yes	No	Yes	No	Yes	No
$\overline{R}^2$	0.488	0.551	0.184	0.317	0.255	0.346	0.143	0.240
N	44,717	36,635	44,710	36,635	37,129	28,454	37,125	28,454

Notes: Regressions were performed with the S&P 500 data (columns 2–5) and with the non-S&P 500 data (columns 6–9) for the 1975:1–97:4 period. The market rate (R_t) and the spread between the prime rate and the market rate (g_t) are in fractions (annual percentage/100). All regressions include the quarter-industry effects. $\overline{R}^2$ excludes variance explained by the fixed-firm effects. Standard errors (in parentheses) are computed using White's correction for heteroscedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and [†] indicates significance at the 10% level.

Table 7. Alternative Regressions for Corporate Liquid Asset Demand

Independent variable	Dependent variable: $\ln m_{j,t}$				Dependent variable: $M_{j,t}/\hat{A}^N_{j,t}$			
	(g)	(h)	(i)	(j)	(g)	(h)	(i)	(j)
$\ln S_{j,t}$	0.981** (0.015)	0.977** (0.015)	0.968** (0.014)	0.968** (0.015)	—	—	—	—
$\ln \hat{V}_{j,t}$	-0.082** (0.013)	-0.089** (0.013)	-0.087** (0.013)	-0.086** (0.014)	—	—	—	—
$S^N_{j,t}/\hat{A}^N_{j,t}$	—	—	—	—	0.050** (0.004)	0.063** (0.005)	0.055** (0.005)	0.054** (0.005)
$\hat{V}^N_{j,t}/\hat{A}^N_{j,t}$	—	—	—	—	-0.151** (0.006)	-0.156** (0.006)	-0.151** (0.006)	-0.148** (0.006)
R_t	-3.803** (0.230)	-3.575** (0.231)	-3.755** (0.230)	—	-0.164** (0.013)	-0.145** (0.013)	-0.157** (0.013)	—
μ_t	1.454** (0.470)	1.369** (0.473)	1.418** (0.470)	2.344** (0.480)	0.093** (0.026)	0.081** (0.027)	0.083** (0.027)	0.130** (0.028)
μ_{t-1}	0.701 (0.493)	0.670 (0.496)	0.679 (0.493)	1.461** (0.500)	0.056* (0.027)	0.047† (0.027)	0.048† (0.027)	0.087** (0.028)
μ_{t-2}	-0.039 (0.480)	0.004 (0.483)	-0.058 (0.480)	0.468 (0.483)	0.032 (0.027)	0.030 (0.027)	0.027 (0.027)	0.053† (0.028)
μ_{t-3}	-0.379 (0.480)	-0.366 (0.483)	-0.410 (0.480)	0.243 (0.487)	-0.014 (0.027)	-0.019 (0.028)	-0.023 (0.028)	0.009 (0.028)
T_t	-0.006** (0.0003)	-0.006** (0.0003)	-0.006** (0.0003)	-0.005** (0.0003)	-4.8×10^{-4}** (1.6×10^{-5})	-4.3×10^{-4}** (1.6×10^{-5})	-4.3×10^{-4}** (1.6×10^{-5})	-4.2×10^{-4}** (1.8×10^{-5})
$R\&D$	7.795** (0.231)	8.503** (0.237)	8.411** (0.228)	8.457** (0.243)	0.511** (0.029)	0.646** (0.029)	0.630** (0.029)	0.639** (0.031)
Tobin's q	0.051** (0.010)	0.054** (0.010)	0.054** (0.010)	0.057** (0.013)	0.019** (0.001)	0.020** (0.001)	0.019** (0.001)	0.022** (0.001)
Debt-equity	-0.145** (0.013)	-0.134** (0.013)	-0.132** (0.013)	-0.136** (0.013)	-0.018** (0.001)	-0.016** (0.001)	-0.017** (0.001)	-0.016** (0.001)
Interest cost	-0.255** (0.012)	-0.259** (0.012)	-0.254** (0.012)	-0.253** (0.012)	-0.020** (0.001)	-0.020** (0.001)	-0.019** (0.001)	-0.019** (0.001)
Dividend dummy	-0.256** (0.023)	—	—	—	-0.047** (0.002)	—	—	—
Account receivables[a]	—	-0.148** (0.013)	—	—	—	-0.064** (0.006)	—	—
Cash-flow Uncertainty	—	—	-7.199 (38.70)	—	—	—	14.23** (2.595)	—
Opportunity cost proxy	—	—	—	-5.837** (0.324)	—	—	—	-0.259** (0.019)
$\overline{R}^2$	0.553	0.553	0.551	0.558	0.341	0.325	0.317	0.321
N	36,562	35,103	36,635	34,556	36,652	35,937	36,635	34,556

Notes: With the S&P 500 data, regressions (g), (h), and (i) were performed for the 1975:1–97:4 period, and regression (j) was performed for the 1975:1–96:2 period. The market rate (R_t) and Federal funds rate (FFR_t) are fractions (annual percentage/100). The quarter-industry effects are included in all regression except regression (i) in which quarter dummies are included. Standard errors (in parentheses) are computed using White's correction for heteroscedasticity. ** indicates significance at the 1% level, * indicates significance at the 5% level, and † indicates significance at the 10% level.

[a] The log of the (beginning-of-quarter) real receivables in the log specification and the (beginning-of-quarter) ratio of receivables–total assets in the ratio specification.

Figure 1. Cross-Section Averages of Liquid Assets, Sales, and Inventories
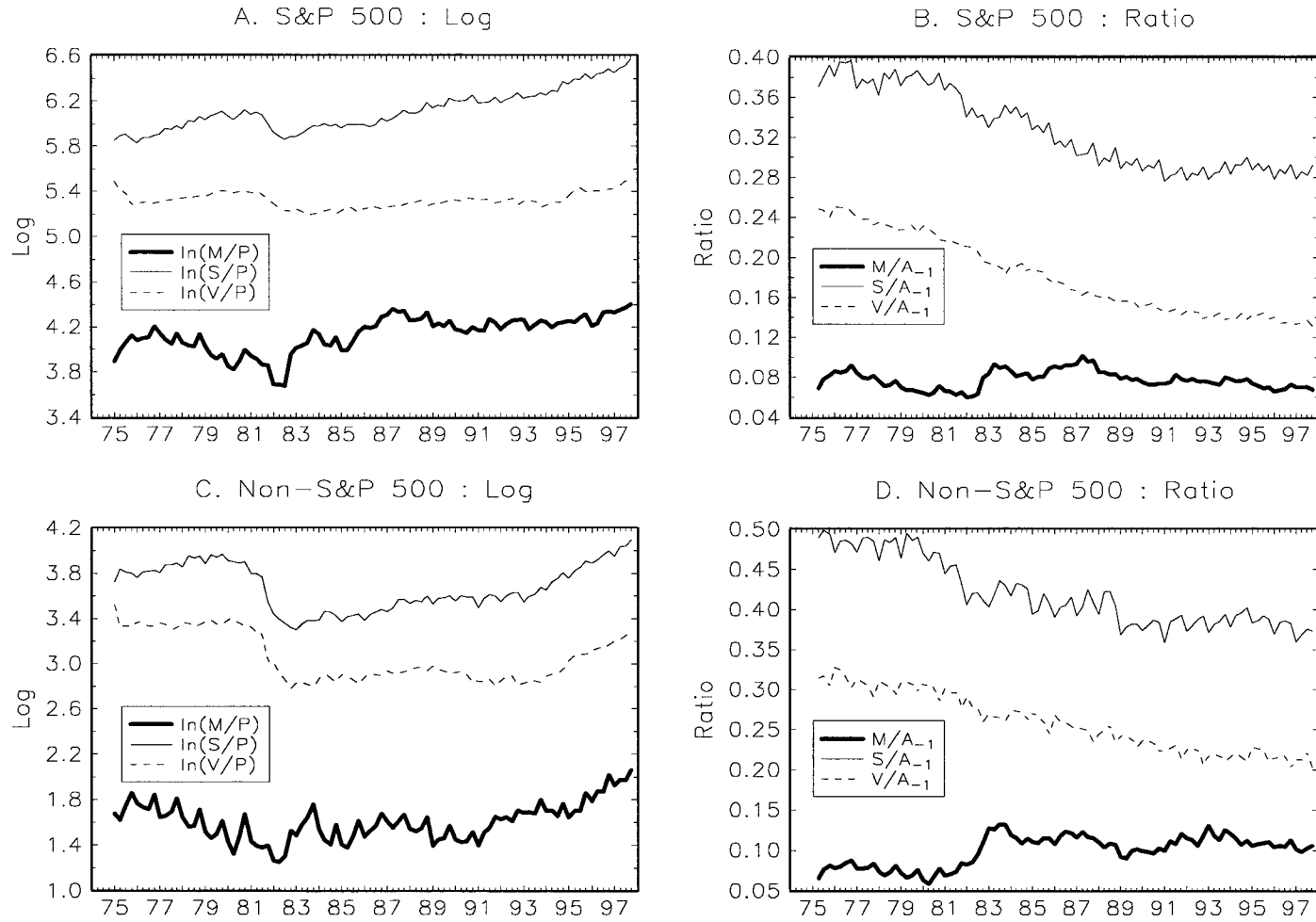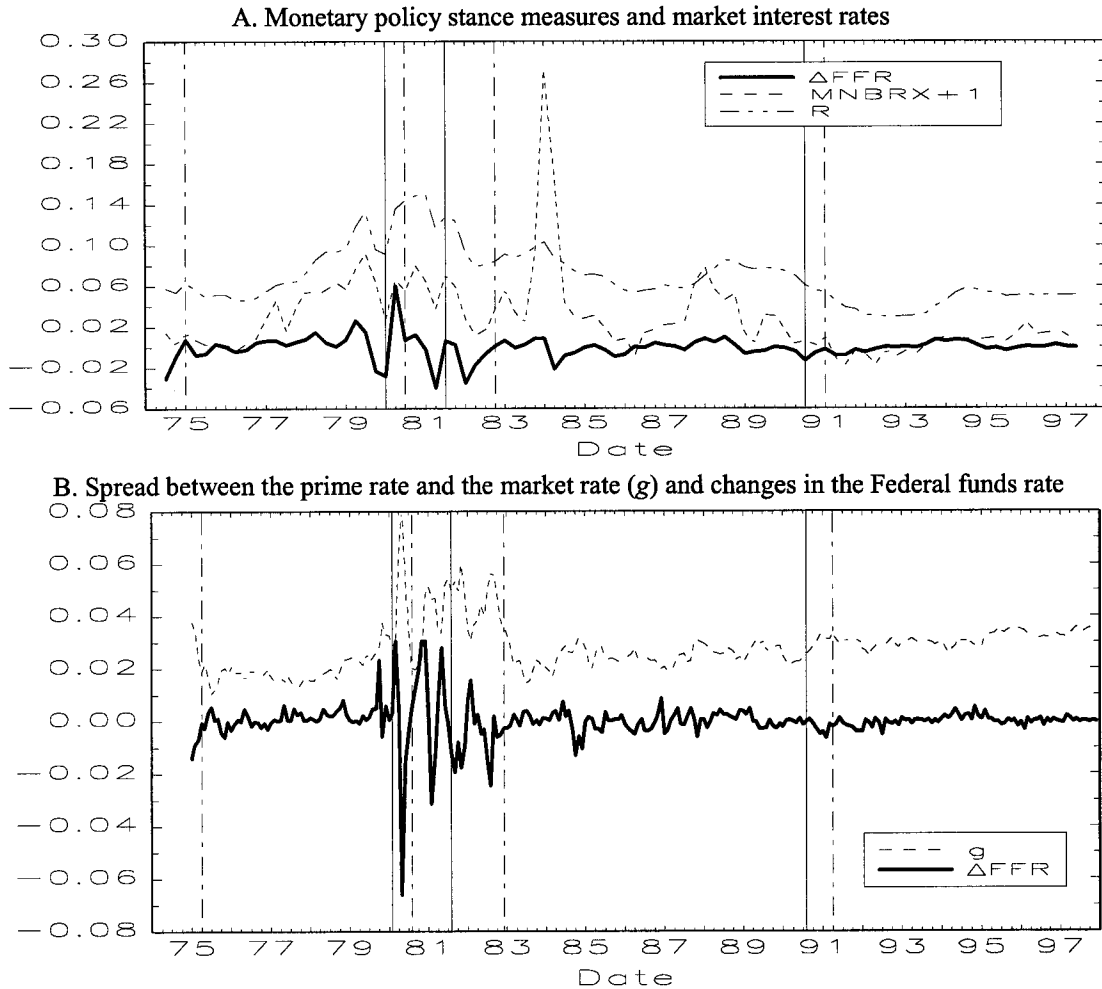

A. S&P 500 : Log

B. S&P 500 : Ratio

C. Non-S&P 500 : Log

D. Non-S&P 500 : Ratio

Figure 2. Monetary Policy Stance Measures and Spread

### A. Monetary policy stance measures and market interest rates

B. Spread between the prime rate and the market rate (g) and changes in the Federal funds rate

Note: Vertical solid lines denote NBER business cycle peaks, and vertical dash-dotted lines denote business cycle troughs.

Figure 3. Distributed Movements of Policy Stance Measures and Aggregated Liquidity near the Onset of Recessions.
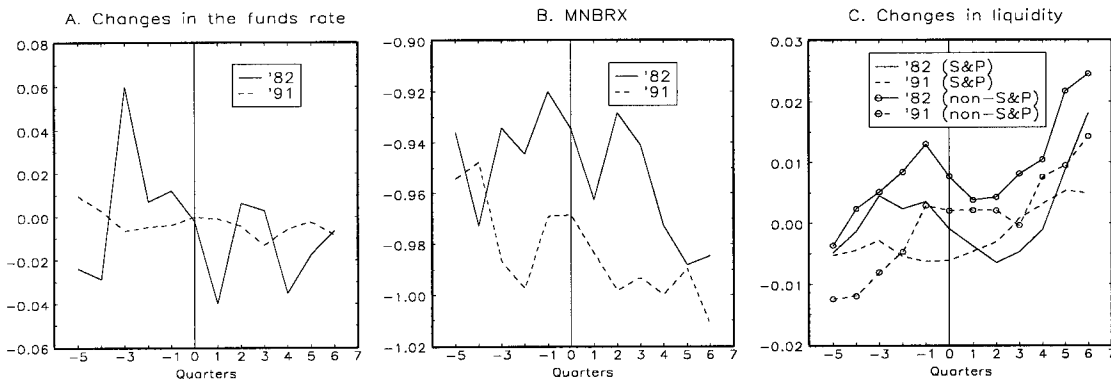

Notes: The horizontal axes represent the number of quarters before (with a negative sign) and after the onset of the 1982 recession (81:4) and the 1991 recession (90:3). For each recession, the curve for a group of firms is the locus of the group mean of j-quarter-ahead variable. Panel C depicts the annualized change in liquidity $(M_t / A_t^N - M_{t-4} / A_{t-4}^N)$. The curves without symbols are for S&P firms and those with symbols are for non-S&P firms.

Figure 4. Impulse Responses to a Policy Tightening Shock
Using a Monthly 5-Variable VAR Model
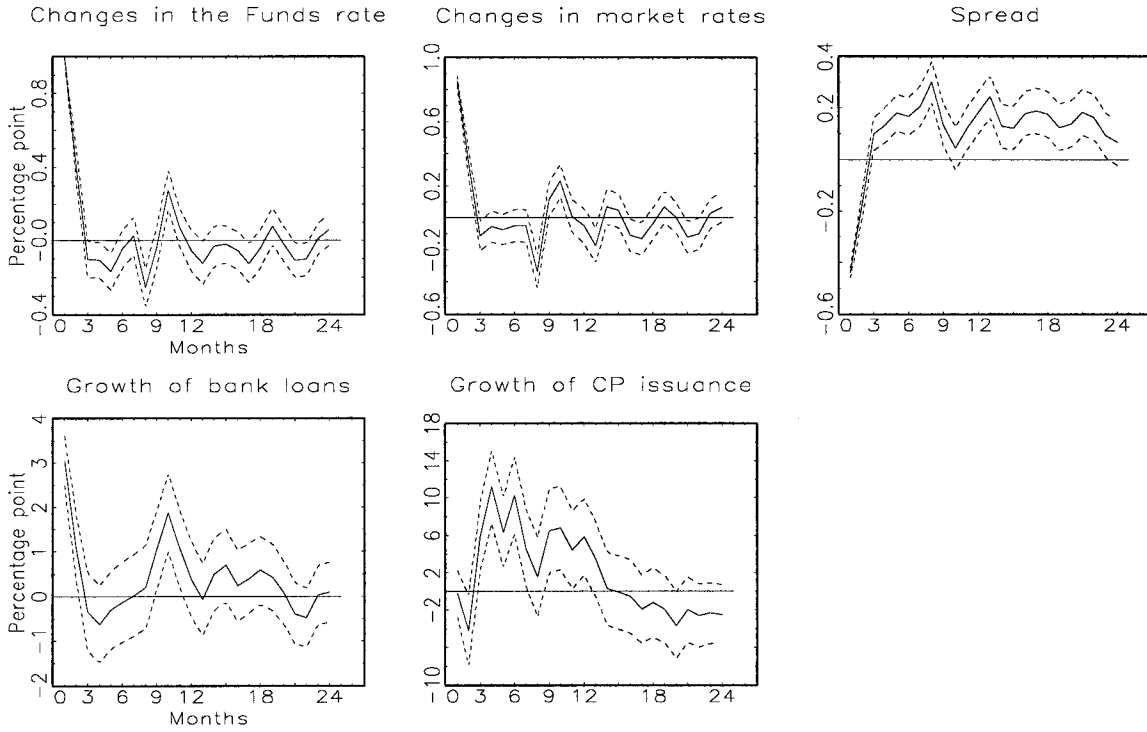
Note: The solid line represents the point estimate, and the dotted lines denote one-standard error bands computed from bootstrapping with 1000 replications.

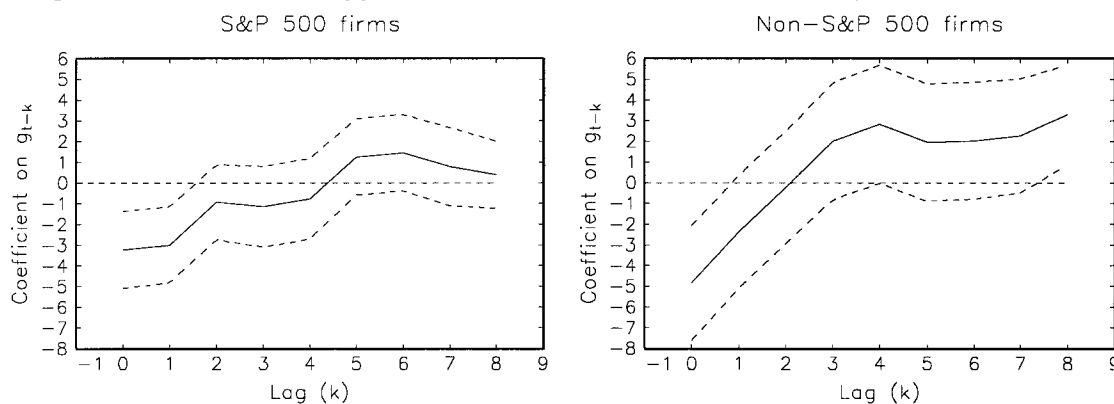Figure 5. Current and Lagged Effects of Tighter Monetary Policy on Liquid Asset Demand
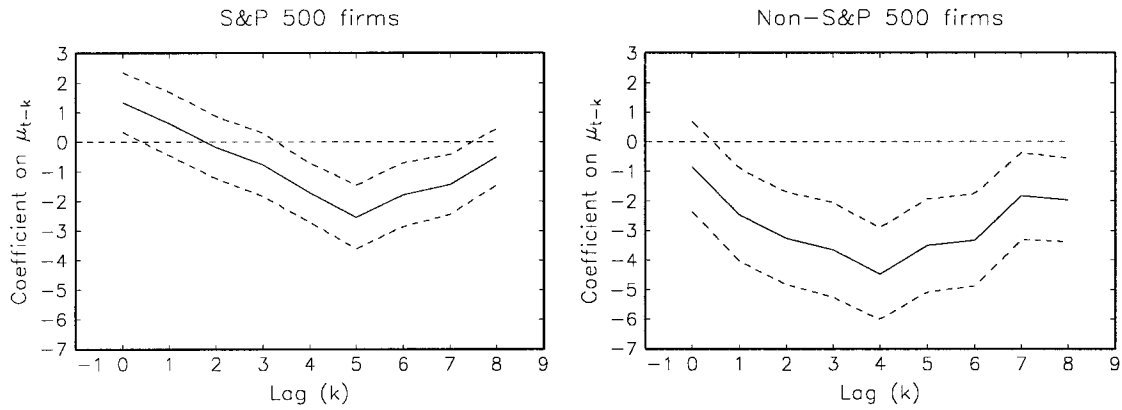
Notes: Coefficient estimates are from the regressions that extend regression (f) of the log specification by including $\{\Delta FFR_{t-k}\}_{k=0}^{8}$. Dashed lines are two-standard error bands.

Figure 6. Bond Ratings and Effects of Tighter Monetary Policy on Liquid Asset Demand
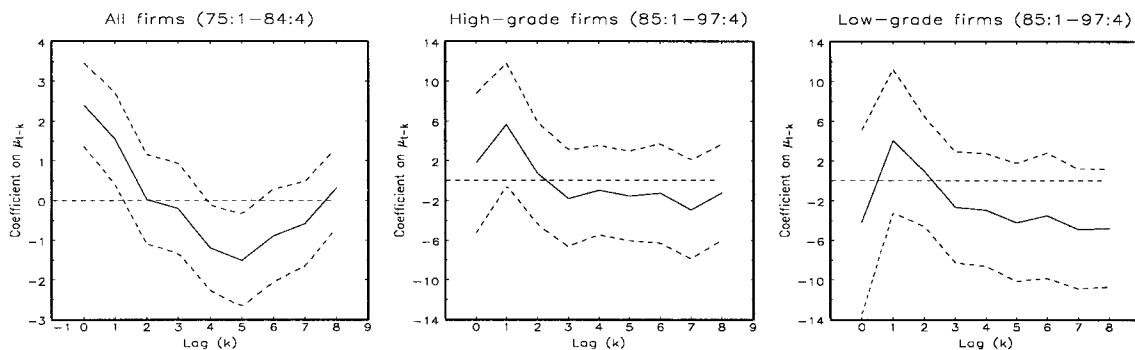
Notes: Coefficient estimates for 1975:1–84:4 (column 1) and for 1985:1–97:4 (columns 2–3) are from the regressions with S&P 500 dataset that extend regressions (f) by including $\{\Delta FFR_{t-k} \cdot Bdum_{j,t}\}_{k=0}^{8}$ and $\{\Delta FFR_{t-k} \cdot (1 - Bdum_{j,t})\}_{k=0}^{8}$, respectively. Dashed lines are two-standard error bands.

Figure 7. Current and Lagged Effects of a Spread Increase on Liquid Asset Demand.

Notes: Coefficient estimates are from the regressions that extend regression (f′) of the log specification by including $\{g_{t-k}\}_{k=0}^{8}$. Dashed lines are two-standard error bands.

Details of the Data

Both S&P and non-S&P firm data sets 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 not currently active.

The non-S&P 500 data set 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, starting from the largest firm; we selected twice as many non-S&P firms as S&P firms. Although they were among the largest non-S&P firms in the sum of sales, their average three-year sales years were not to 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, totalling 689 firms.

Since S&P firms tend to have a long listing history, we gave priority to the non-S&P firms with greater sums of sales of the 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 lists the number of included firms by date among the total of 659 S&P firms and 689 non-S&P firms in the sample. The number of S&P firms is relatively stable over time except for the initial few years, while that of non-S&P firms shifts up in the early 1980s indicating more firms with consecutive observations in later periods. Table A.1 reports the summary statistics for non-S&P firms.

Table A.1. Descriptive Statistics for the Non-S&P Firm Data Set

Variable	N	Mean	Standard deviation	Minimum	1st quarter	Median	3rd quarter	Maximum
$\ln m_{j,t}$	39,158	1.610	1.716	−5.081	0.568	1.764	2.837	7.071
		[0.000] [a]	[1.708]	[−7.087]	[−1.044]	[0.161]	[1.227]	[5.609]
$\ln S_{j,t}$	39,158	3.650	1.130	−5.081	3.041	3.766	4.397	7.280
		[0.000]	[1.112]	[−9.119]	[−0.596]	[0.107]	[0.738]	[3.679]
$\ln V_{j,t}$	38,169	3.008	1.307	−5.073	2.287	3.205	3.902	7.205
		[0.000]	[1.294]	[−8.271]	[−0.718]	[0.174]	[0.868]	[4.232]
$M_{j,t}/\hat{A}^N_{j,t}$	38,189	0.104	0.142	0.000	0.018	0.049	0.136	2.840
		—	—	—	—	—	—	—
$S^N_{j,t}/\hat{A}^N_{j,t}$	38,189	0.409	0.287	0.000	0.266	0.365	0.480	15.75
		—	—	—	—	—	—	—
$V^N_{j,t}/A^N_{j,t}$	38,189	0.249	0.167	0.000	0.130	0.229	0.339	3.180
		—	—	—	—	—	—	—
R&D /sales	39,158	0.025	0.215	0.000	0.000	0.000	0.021	23.60
		—	—	—	—	—	—	—
Tobin's q	35,639	1.483	0.954	0.082	0.961	1.201	1.649	16.18
		[0.003]	[0.921]	[−1.695]	[−0.474]	[−0.227]	[0.151]	[14.33]
Debt /equity [b]	36,945	0.042	0.964	−3.484	−0.558	0.027	0.560	8.164
		[0.000]	[0.961]	[−3.558]	[−0.590]	[−0.013]	[0.517]	[8.100]
Interest cost [b]	32,682	−4.649	0.817	−9.947	−4.943	−4.488	−4.150	0.157
		[0.000]	[0.796]	[−5.012]	[−0.276]	[0.156]	[0.481]	[4.758]

Notes: Distributions of variables are computed with the non-S&P 500 data (689 firms in 46 industries) for the 1975:1–97:4 period. The CPI is used to convert all current dollars into 1992 dollars in measuring all real variables.
[a] Figures in square brackets are statistics of the variable adjusted for cross-section average.
[b] Debt–equity and interest cost ratios are in logarithms.

Figure A.1. Number of Firms by Date
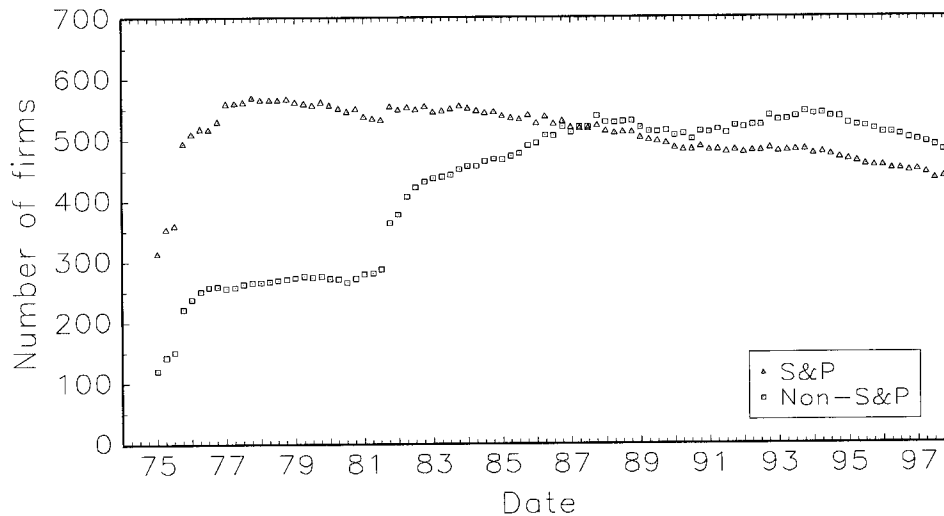
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