Facing Up to Our Ignorance about Measuring Monetary Policy Effects

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Macroeconomists have a reputation for disagreeing about almost everything. Deserved or not, that reputation encourages decisionmakers to view economists' advice and predictions with skepticism. The disagreements among economists stem in large part from differences of opinion about the economic behavior underlying observed data, differences that can be resolved only through economic research explicitly demonstrating the linkage of movements in economic variables with the actions of specific players in the economy. Such efforts to build a consensus make economists' predictions more credible and thus more useful to decisionmakers.

One important phenomenon on which there is widespread agreement, however, is that an increase in the money supply lowers the interest rate in the short run. This "liquidity effect" plays a central role in popular, political, and academic discussions of monetary policy. Casual discussions that equate "high" interest rates with "tight" monetary policy implicitly assume that the liquidity effect exists.[1]

The liquidity effect is important because it is the channel through which monetary policy affects the economic conditions that policymakers want to influence. Although the Federal Reserve ultimately wants to influence such things as output and inflation, it cannot control these variables directly. However, over time horizons that are relevant for policy, the Fed can directly control a monetary measure that appears on its balance sheet. At the same time, there is strong evidence that interest rates are correlated with future movements in output and prices. The liquidity effect, therefore, is the nexus between what the Fed can influence directly and what the Fed ultimately seeks to influence. The goal of current empirical research on the liquidity effect is to establish stable relationships between a monetary measure

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and interest rates and between interest rates and other variables in the hopes of finding stable relationships between a controllable variable and the variables that monetary policymakers want to influence. Understanding the relationship between money growth and the interest rate is important for practical policymaking.

The economic profession's consensus that the liquidity effect exists can be seen in the many theoretical analyses that build in the liquidity effect as the first step in the process for transmitting monetary policy effects to the rest of the economy. The liquidity effect is a critical element in traditional Keynesian models (based on James Tobin's 1947 work) and in the monetarist approaches of Milton Friedman (1968) and Phillip Cagan (1972). Recent neoclassical models (for example, Robert E. Lucas, Jr. 1990 and Timothy S. Fuerst 1992) have included the liquidity effect to remedy the apparent deficiency of earlier neoclassical models in which monetary expansions tend, if anything, to raise the nominal interest rate.[2]

Although most economists believe that the liquidity effect exists, the profession is far from a consensus on a way to measure the effects of monetary policy on the interest rate. The disagreements arise mostly because empirical work on the liquidity effect has traditionally made incredible assumptions about both private and policy behavior. Without first specifying plausible behavior, it is impossible to make credible predictions of the effects of policy.

This article reinterprets the traditional empirical work and explores various ways to quantify the liquidity effect by presenting a largely atheoretical characterization of the relationship between the federal funds rate (a short-term interest rate) and the monetary base (currency in circulation plus bank reserves) over the 1954-91 period.[3] For much of this period, the Fed targeted the federal funds rate by conducting open market purchases and sales of U.S. Treasury securities. These open market operations affected the amount of reserves the Fed provided to the banking system, thereby affecting the monetary base. Thus, although the Fed has never targeted the monetary base per se, it achieves its targeted level of the federal funds rate through open market operations that necessarily influence the base.

The article also considers whether the relationship between the funds rate and the monetary base is stable over four subperiods that are commonly viewed as reflecting different policy environments. The research replicates the pattern of correlations traditionally interpreted as evidence of the liquidity effect and shows that this pattern is sensitive to which variables are held fixed when the correlations are calculated. For example, when lagged interest rates, consumer prices, and industrial production are held fixed, as the traditional theory of the liquidity effect suggests they should be, all evidence of the liquidity effect disappears: the correlation between unexpected changes in money growth and the interest rate is zero or positive.[4] In addition, the study finds that the relationships between the funds rate and the monetary base are unstable, changing sign and size across the four subperiods considered.

These results lead to one of two possible conclusions: either the widespread belief in the existence of the liquidity effect is incorrect, or the observed short-run correlations between money growth and the interest rate do not primarily reflect the liquidity effect. The latter conclusion seems more likely. The traditional theoretical analysis of the liquidity effect is based entirely on demand-side behavior. Using the traditional analysis to interpret correlations requires assuming that the data are dominated by money demanders' responses to changes in monetary policy. It is more likely, however, that the correlations arise in large part from the responses of monetary policy to changes in economic conditions. The findings reported here underscore the need to separate money-supply and money-demand behavior carefully when estimating and interpreting the effects of monetary policy on the interest rate.

In addition to discussing the traditional theoretical analysis of the liquidity effect and the money growth/interest rate correlations that the analysis implies, this article examines ways the analysis is used to interpret data. The article defines what it means to "identify" economic behavior and uses the example of the liquidity effect to show how failure to identify an economic model can lead to misleading interpretations of the data. This discussion leads to a simple way to think about how to use data to isolate the monetary policy shocks that generate the liquidity effect. Finally, there is a description of the data set used to characterize the liquidity effect and a report on the empirical results.

By raising questions about the nature of the relationship between money growth and the interest rate, this article argues that the economics profession is woefully ignorant about how to measure this most immediate and fundamental effect of monetary policy. Without thoroughly understanding the liquidity effect, the profession cannot claim to understand precisely the effects of monetary policy on inflation, output, or other economic variables.

The Traditional Analysis of the Liquidity Effect

The traditional theoretical analysis of the liquidity effect, as presented in Friedman (1968) or Cagan (1972), abstracts from many real-world complications to focus entirely on the behavior of money demanders. The analysis implies that an increase in the rate of growth of the money supply, holding income and prices constant in the short run, causes the nominal interest rate to fall (see the money market graph in Chart 1).

The theory assumes that the demand for real (or inflation-adjusted) money balances depends on a short-term nominal interest rate, R, and real income (or the level of transactions), y:

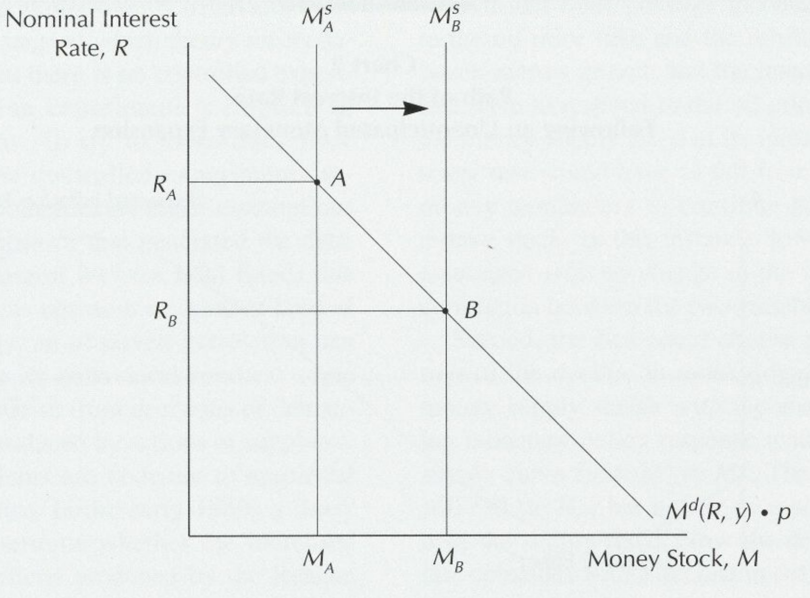
$$\frac{M_t^d}{p_t} = M^d(R_t, y_t), \tag{1}$$

where M^d is the quantity of nominal balances demanded, p is the general price level, and M^d/p is the demand for real balances. The subscripts denote variables measured at date t. The nominal interest rate represents the opportunity cost of holding money. As this opportunity cost rises, demanders will substitute out of money and into assets that earn the increasing rate of return, decreasing the quantity of money demanded. This negative interest elasticity of money demand produces the downward-sloping demand curve in Chart 1. Higher income boosts the transactions demand for money, and demanders will want to hold more money at any given interest rate, shifting the demand curve to the right.

Drawing the supply of money, M^s, vertically implies that the Fed does not adjust the money supply in response to changes in the interest rate. The traditional theoretical analysis typically assumes that the Fed also sets the money supply independently of the level of income and prices. These assumptions correspond to treating monetary policy as exogenous, or unrelated to prevailing economic conditions. Treating monetary policy as exogenous amounts to assuming that changes in the money supply are arbitrary and random.

Equilibrium in the money market occurs at the point where demand and supply coincide: $M^d = M^s$. In the short run, because income and prices are treated as fixed, the money market determines the equilibrium levels of the money stock and the nominal interest rate.

Chart 1
The Money Market: Conceptual Experiment Underlying the Liquidity Effect



To generate the liquidity effect, consider the following exercise: The Fed conducts an open market purchase of Treasury securities, increasing bank reserves. An open market purchase shifts the money-supply curve outward from M_A^s to M_B^s. In the short run the nominal interest rate must fall to induce money demanders to slide down their stable demand curve from point A to point B and hold the new higher level of both nominal and real money balances. This response of demanders produces the liquidity effect.

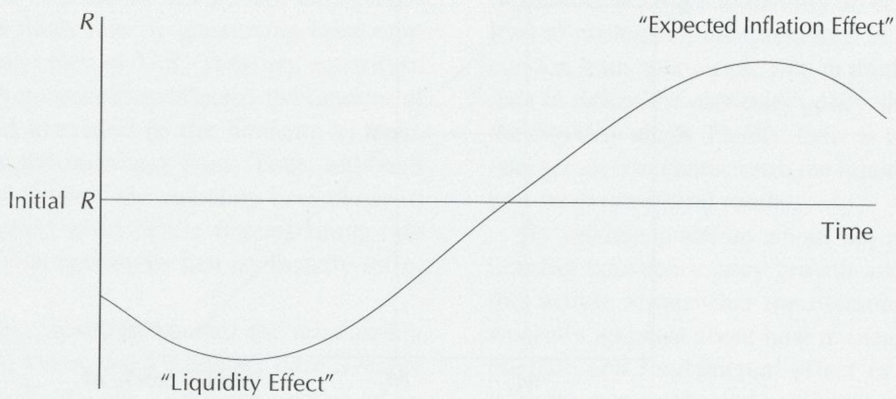
Eventually, actual (and expected) inflation will adjust to the higher growth rate of money, and bondholders will drive up the nominal interest rate to maintain the premonetary expansion real return on bonds; the long-run correlation between money growth and the nominal interest rate is positive.[5] The long-run tendency for changes in money growth to be reflected in expected inflation, and, thus, the nominal interest rate, is the "expected inflation effect." The negative interest elasticity of money demand produces the liquidity effect in the short run, but in the long run the expected inflation effect dominates the liquidity effect. Chart 2 graphs the path of the nominal interest rate that the traditional theoretical analysis predicts will follow a monetary expansion.[6]

In recent extensions of this theory, the sooner people come to expect a monetary expansion, the sooner the expected inflation effect begins to dominate the liquidity effect and the milder and briefer the decline in the interest rate will become. The modern models associated with Lucas (1990) and Fuerst (1992) employ an extreme version of this logic: only unanticipated increases in the money supply can lower interest rates. Anticipated changes in money growth immediately affect the expected inflation rate, driving up the nominal interest rate and producing only the expected inflation effect.

Many researchers have used the traditional theory of the liquidity effect to interpret data. If the analysis in Chart 1 completely described observed movements in the nominal interest rate and money growth, the two variables would be negatively correlated in the short run and positively correlated in the long run. Researchers such as Lawrence J. Christiano (1991) and Christiano and Martin Eichenbaum (1991a) explicitly interpret the short-run correlations as reflecting the liquidity effects of monetary policy that Chart 1 depicts.

Other researchers regress the interest rate against current and past monetary aggregates and interpret the regression coefficients as measures of the effects of monetary policy on interest rates (see, for example, Cagan 1966, 1972; Cagan and Arthur Gandolfi 1969; William E. Gibson 1970a, 1970b; and Michael Melvin 1983). Recent empirical work tries to isolate unanticipated changes in the money supply and traces out the response of the interest rate to unanticipated monetary expansions (see John H. Cochrane 1989; Christiano and Eichenbaum 1991b; Vefa Tarhan 1991; and Steven Strongin 1991).

Chart 2
Path of the Interest Rate
Following an Unanticipated Monetary Expansion



*I*dentifying Money-Demand and Money-Supply Behavior

Because the traditional theory of the liquidity effect holds many variables fixed, the correlations between observed money growth and interest rates frequently cannot be interpreted directly in terms of Chart 1. The theory is entirely a demand-side story that relies on the Fed's expanding the money supply for reasons that do not simultaneously shift the money-demand curve. With no explanation of why the Fed chooses its policy, the traditional analysis provides no guidance about when an observed change in the money supply corresponds to the supply shift depicted in Chart 1. When researchers apply the traditional theory directly to interpret correlations, they implicitly assume that every change in the money supply arises for reasons that do not perturb the stable money-demand curve. In practice, however, the Fed frequently changes the money supply in response to shocks that also shift money demand. When the variation in money-supply shocks is not independent of money demand, simple statistical methods cannot distinguish how much of the money growth/interest rate correlation is owing to the liquidity effect and how much of the correlation arises from the dependence of money supply and interest rates on other variables. To sort out which empirical regularities should be explained by the liquidity effect and which are products of the response of monetary policy to economic conditions, econometricians seek to identify money-demand and money-supply behavior.

Identification is the stage at which theory meets data. In applied economics there is no controlled experiment, although such an experiment is implicit in theoretical discussions. To try to make data more closely conform to the controlled experiments assumed by theory, econometricians make assumptions about the economic behavior that generated the data. These assumptions "control for" (or hold fixed) one kind of behavior to focus attention on another kind of behavior. Consequently, an observed correlation can then be separated into its behavioral sources: some movements of the data arise from decisions of demanders while others are produced by actions of suppliers.

Identification problems are endemic to empirical work in macroeconomics. In the early 1980s a flurry of work sought to determine whether the increased federal government deficits produced by the Reagan Administration's tax cuts would drive up interest rates. Most theoretical models imply an affirmative answer. Most empirical work concluded either that there was no relationship or that higher deficits are associated with lower interest rates. The perverse negative correlations arise from researchers' failure to control for the fact that deficits are countercyclical and interest rates are procyclical: during recessions government revenues automatically decline, and government expenditures automatically rise at the same time that interest rates tend to fall. If such cyclical fluctuations are the dominant source of movements in deficits and interest rates, simple statistical methods will find that the two variables are negatively correlated. Implicitly the empirical work equates all observed changes in deficits with the conceptual experiment performed in theoretical models of fiscal policy. The researchers have not plausibly identified the theoretical experiment in the data, making the predictions about the interest rate effects of tax cuts unbelievable.

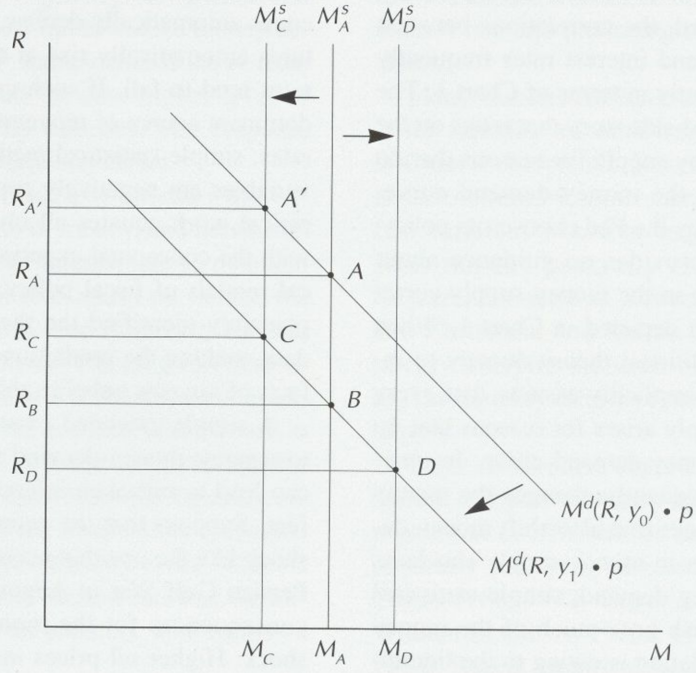
A simple extended example illustrates how failing to separate money-demand and money-supply behavior can lead to mistaken inferences about the liquidity effect. Suppose that the economy is hit by an oil price shock like the one that occurred at the beginning of the Persian Gulf War in August 1990. Chart 3 shows the consequences for the money market of an oil price shock. Higher oil prices increase the relative price of energy, which is an input for producing a wide range of goods and services. Producers respond to the higher oil price by cutting back on employment and output. Income falls from y_0 to y_1, decreasing money demand and shifting the money-demand curve from $M^d(R, y_0) \bullet p$ to $M^d(R, y_1) \bullet p$.

Consider three possible monetary policy responses to the oil price hike and the resulting correlations between money growth and the interest rate. First, if the Fed were to respond to the oil price shock by keeping the money supply fixed at its initial level, M^s_A, the interest rate would have to fall from R_A to R_B to induce money demanders to continue holding the existing money stock. In this instance, lower interest rates are associated with no change in the money stock, so the correlation between the two variables is zero.

Second, the Fed could choose partial accommodation of the decline in money demand by making the money supply shrink with income. An accommodating monetary policy response would shift the money-supply curve from M^s_A to M^s_C. The interest rate would still fall (to R_C) but not by as much as if the Fed had held the supply fixed. Now the decline in the interest rate coincides with a decline in the money growth rate, so the correlation is positive.

Third, if the Fed were concerned with trying to offset the deleterious employment and output effects of

Chart 3
Possible Monetary Policy Responses to an Oil Price Increase



The oil price increase reduces income from y_0 to y_1, shifting money demand from $M^d(R, y_0) \bullet p$ to $M^d(R, y_1) \bullet p$. The variable M_A^s is the initial money supply, M_C^s is the money supply when the Fed partially accommodates the decline in money demand, and M_D^s is the money supply when the Fed tries to offset the decline in the income by expanding the money stock.

the oil price shock, it could instead expand the money supply to M_D^s, driving the interest rate still lower to R_D. This policy response produces a negative correlation between money growth and the interest rate.

The example illustrates that, although assumptions about private behavior remain the same in the three policy scenarios (namely, that the interest elasticity of money demand is negative), the resulting correlation between money growth and the interest rate varies with assumptions about policy behavior. The reason for the result is straightforward: neither the increase nor the decrease in the money supply in the last two cases corresponds to the conceptual experiment underlying the liquidity effect in Chart 1. To deduce that the different correlations arise from different policy behavior, it is necessary to dispense with simple correlations and control the experiment by making specific assumptions about how the Fed responds to oil price shocks.

The simple correlations experience an identity crisis because the correlations cannot help decompose the ultimate decline in the interest rate into the amount based on demanders' behavior and that resulting from the supplier's behavior. Suppose that instead of relying on simple correlations, a model that fully identified the behavior underlying Chart 3 were constructed—that is, estimates of how money demand depends on the interest rate and income and how money supply depends on income were available. Then the movement from the equilibrium at point A to the equilibrium at point C, which arose when the Fed partially accommodated the decline in money demand, could be decomposed into two parts: (1) the increase in the interest rate caused by moving from A to A' up the initial demand curve (the demand response to a shift in supply) and (2) the decrease in the interest rate based on moving from A' to C on the new lower demand curve (the interest rate response to a decline in income). The liquidity effect can then accurately be identified as the negative correlation produced by demanders moving along their initial demand curve from A to A' as the money supply contracts.

Specifying Policy to Recover the Liquidity Effect

To recover the liquidity effect of monetary policy, it is not necessary to identify money-demand and money-supply behavior completely, as in the example. If disturbances that shift the M^s curve but do not shift the M^d curve can be isolated—that is, if the monetary policy shock is identified—it is possible to calculate the resulting change in the interest rate and attribute the full change in the interest rate to demanders sliding along a fixed demand curve. This approach has been taken by many researchers recently (see, for example, Christopher A. Sims 1986, 1988; Christiano and Eichenbaum 1991b; Strongin 1991; and Tarhan 1991).

Surprisingly, monetary theorists traditionally have modeled monetary policy behavior as an arbitrary, random process. This assumption is made implicitly in empirical work by Cagan (1972), Cagan and Gandolfi (1969), Gibson (1970a, 1970b), and Melvin (1983), to name a few, and explicitly by Cochrane (1989), Christiano (1991), Christiano and Eichenbaum (1991a), and Robert G. King (1991). In effect, these researchers treat today's value of the money growth rate as the outcome of the spin of a roulette wheel.[7]

Any serious specification of monetary policy must recognize that the Fed behaves purposefully. The Fed tries to fulfill its congressional mandate to stabilize the economy by making adjustments to the growth rate of money based on a vast array of information. To the extent that the congressional mandate does not change and the economic environment evolves only gradually, the Fed's purposeful behavior will have a large systematic component.[8]

Even if the Fed behaves purposefully and systematically, there will remain some aspect of policy choices that cannot be predicted by private decisionmakers in the economy.[9] The unpredictable part of policy choice could arise from the fact that private agents are uncertain about the weights that members of the Federal Open Market Committee will place on various monetary policy objectives when they vote on policy decisions.[10] The implication is that the Fed's choice of the money supply can be modeled as depending on information the Fed knows at the time of the decision plus a random error, which is revealed to private decisionmakers only at the time the policy choice is made.

$$M_t^s = M^s(Z_t) + \epsilon_t. \qquad (2)$$

The variable Z_t, which summarizes the information available when the Fed chooses the money supply at time t, may include such things as the unemployment rate, income, prices, interest rates, exchange rates, commodity prices, past monetary aggregates, and so on.[11] $M^s(\bullet)$ is a function that translates the information into a systematic policy choice, and ϵ_t is the aspect of policy choice that appears to be random from the perspective of private agents. The policy shock ϵ cannot be predicted from past information, implying that, given information available today, the private sector's best guess of ϵ tomorrow is zero.

The specification of policy behavior in equation (2) can be coupled with the money-demand behavior in equation (1) to produce a new graph analogous to Chart 1, except that the money-supply curve is no longer vertical. For example, if the Fed increases the money supply in response to increases in the interest rate, the supply curve will be positively sloped. In addition, fluctuations in prices and income, which shift the money-demand curve, may also shift the money-supply curve if these variables are part of the information to which the Fed responds systematically—the Z_t. By assumption, however, disturbances to ϵ_t are shocks that shift the supply curve for money but do not shift the demand curve. Moreover, because the value of ϵ is unpredictable one period ahead, disturbances to ϵ reflect unanticipated shifts in the money-supply curve. If an econometrician can extract a time series of ϵ's from the data, she can conduct the controlled experiment in Chart 1 by perturbing ϵ and tracing out the resulting path of the interest rate. All empirical work on the liquidity effect requires making some assumption about how to extract the time series of ϵ's from the data.[12]

Data Considerations

The empirical part of this study evaluates the traditional interpretation of money growth/interest rate correlations as primarily reflecting the liquidity effect. The work concentrates on relationships between the monthly series for the monetary base and the federal funds rate. The monetary base is chosen for two reasons. First, as the sum of two liabilities on the Fed's balance sheet, the monetary base is closely associated with the open market operations that underlie the liquidity effect. Second, the monetary base is a variable over which the Fed can exert control, although the Fed has chosen to passively supply some components of the base, such as currency.[13]

In addition to its being the Fed's target variable during much of the 1954-91 period, there are two virtues to using the federal funds rate. First, the funds rate is extremely short term, a characteristic that helps separate liquidity effects from expected inflation effects without imposing a theory of the term structure and expected inflation. Second, for data at a monthly frequency interest rates with maturity structures longer than one month would need to be converted to one-month holding period returns (as, for example, Frederic S. Mishkin 1983 does).

Mimicking the theoretical liquidity experiment in Chart 1 requires monthly data on the price level and income. The consumer price index is used for the price level, and industrial production is used for income. As a gauge of manufacturing output, industrial production clearly is not an ideal monthly measure of income, but its use allows these results to be compared with those from other empirical studies, which use industrial production as a proxy for income.

Some previous work found that the correlations between money growth and the interest rate change over time. To investigate this possibility, the post–Korean War period is subdivided into four nonoverlapping periods that reflect different policy environments: 1954:7 to 1972:12, 1973:1 to 1979:9, 1979:10 to 1982:11, and 1982:12 to 1991:11. The relationships are also estimated over the full 1954:7 to 1991:11 period. Several considerations guided the choice of subperiods. Marvin Goodfriend (1991) lists the 1950s, 1960s, and the period since 1982 as times when the Fed indirectly targeted the funds rate, suggesting from 1954 to 1972 and from 1982 to 1991 as subperiods. Melvin (1983) writes of the "vanishing liquidity effect" after 1972, when the United States moved to a flexible exchange rate system. The early 1970s also saw the Fed gradually shift to targeting the funds rate tightly (see Timothy Cook and Thomas Hahn 1989 and Goodfriend 1991), leading to the choice of the 1973 to 1979 period. Finally, Cochrane (1989) shows the liquidity effect returns during the October 1979 to November 1982 period when the Fed targeted nonborrowed reserves.

Estimation and Empirical Results

The data set and estimation techniques used in this research can replicate the results from traditional regression analyses that have been interpreted as evidence of the liquidity effect. In particular, an unanticipated monetary expansion is followed by the path of interest rates depicted in Chart 2. The traditional regressions, however, impose strong and unrealistic restrictions on the relationship between money growth and the interest rate. When these restrictions are relaxed, all evidence of the liquidity effect disappears.

Traditional Regressions with Exogenous Money Growth. The traditional empirical approach to measuring the liquidity effect, associated with Cagan and Gandolfi (1969) and others, estimates a relationship between the interest rate and current and past money growth rates:[14]

$$r_t = \alpha + \beta_0 \rho_t + \beta_1 \rho_{t-1} + \ldots + \beta_n \rho_{t-n} + \eta_t \qquad (3)$$
$$= \alpha + \sum_{j=0}^{n} \beta_j \rho_{t-j} + \eta_t,$$

where r is the level of the federal funds rate, ρ is the growth rate of the monetary base, and η is a regression error term.[15] Each of the β coefficients is an estimate of the correlation between the federal funds rate and money growth at some date. For example, β_0 reports the correlation between the funds rate this month and money growth this month, after controlling for the influence of past money growth rates on this month's funds rate; β_1 is the correlation between the funds rate this month and money growth last month, holding fixed the influence of current and more distant lags of money growth. Leeper and Gordon (1992) report estimates of the β coefficients from this regression that closely resemble those found by earlier researchers.

Recent monetary theories emphasize that unanticipated changes in money growth produce the liquidity effect while anticipated changes in money growth produce only the expected inflation effect. To give the traditional work a modern twist it is necessary to construct a time series of unanticipated changes in money growth. In the spirit of the interpretations that Cagan and others give to their traditional regression results, this study initially maintains the assumption that money growth is exogenous so that an unanticipated change in money is the change that cannot be predicted using past money growth rates.[16] Thus, appended to equation (3) is a description of how money growth evolves over time:

$$\rho_t = \delta_0 + \sum_{i=1}^{n} \delta_i \rho_{t-i} + \epsilon_t. \qquad (4)$$

This equation assumes that the Fed's systematic choice of money growth today depends only on past money growth rates. Much of the existing empirical work on the liquidity effect implicitly treats this specification of money growth as a description of monetary policy behavior, so the Z_t variable in equation

(2) includes only money growth rates for dates $t-1$ and earlier. The variable ϵ_t, which is the part of policy choice that the private sector cannot predict from past information, is called an "innovation" to current money growth. To mimic the conceptual experiment in Chart 1, this empirical work interprets perturbations in ϵ_t as shifts in the money-supply curve and uses equation (4) to produce a time path for money growth. The path for money growth is fed into equation (3) to produce a predicted path of the interest rate.

Chart 4 reports the path of the federal funds rate implied by estimating the econometric model in equations (3) and (4) during each of the sample periods. The path shows how the interest rate moves for thirty-six months following a one-time unanticipated change in the growth rate of the monetary base of one percentage point. When both dashed lines lie above (or below) the zero axis, the interest rate is significantly higher (or lower) than its value before the money growth innovation.

In Chart 4 monetary base innovations have a negative contemporaneous correlation with the funds rate for all periods except the one from 1973 to 1979. The path of the interest rate during the 1954-72 period closely matches Friedman's (1968) traditional description of the effects of a monetary expansion, shown in Chart 2. The average response shows that the funds rate declines at impact and stays below its initial level for nine months; three years after the innovation in the money growth rate, the funds rate is significantly above its initial level.

Melvin's "vanishing liquidity effect" is the difference in the funds rate paths between the 1954-72 and 1973-79 periods. In the latter period, the funds rate response to a monetary base innovation is zero or positive over the full thirty-six-month horizon. Melvin attributes this response to enhanced inflation sensitivity that led the expected inflation effect of a monetary expansion to dominate the liquidity effect. As Cochrane found, the funds rate response is sharply negative during the 1979-82 period, when an innovation in the base is associated with a forty-basis-point decline in the funds rate at impact. The interest rate is persistently lower in the 1982-91 period.

Chart 4 also underscores how misleading it may be to estimate relationships over the full postwar sample. Although the interest rate path for the 1954-91 period is close to that described by Friedman, the path is an average of very disparate patterns of responses over the four subperiods.

Vector Autoregression with Exogenous Money Growth. The estimation procedures underlying Chart 4 impose very strong assumptions about how the interest rate and money growth rates are related. By relating the interest rate only to current and past money growth rates, equation (3) assumes that if other variables help determine the interest rate, the other variables do so only through their influence on the money supply. Equation (4) assumes that only past growth rates of the money supply help to predict the current growth rate. More generally, equations (3) and (4) assume that no other variables induce interest rates and money growth to move together to generate the correlations estimated in traditional regressions.[17]

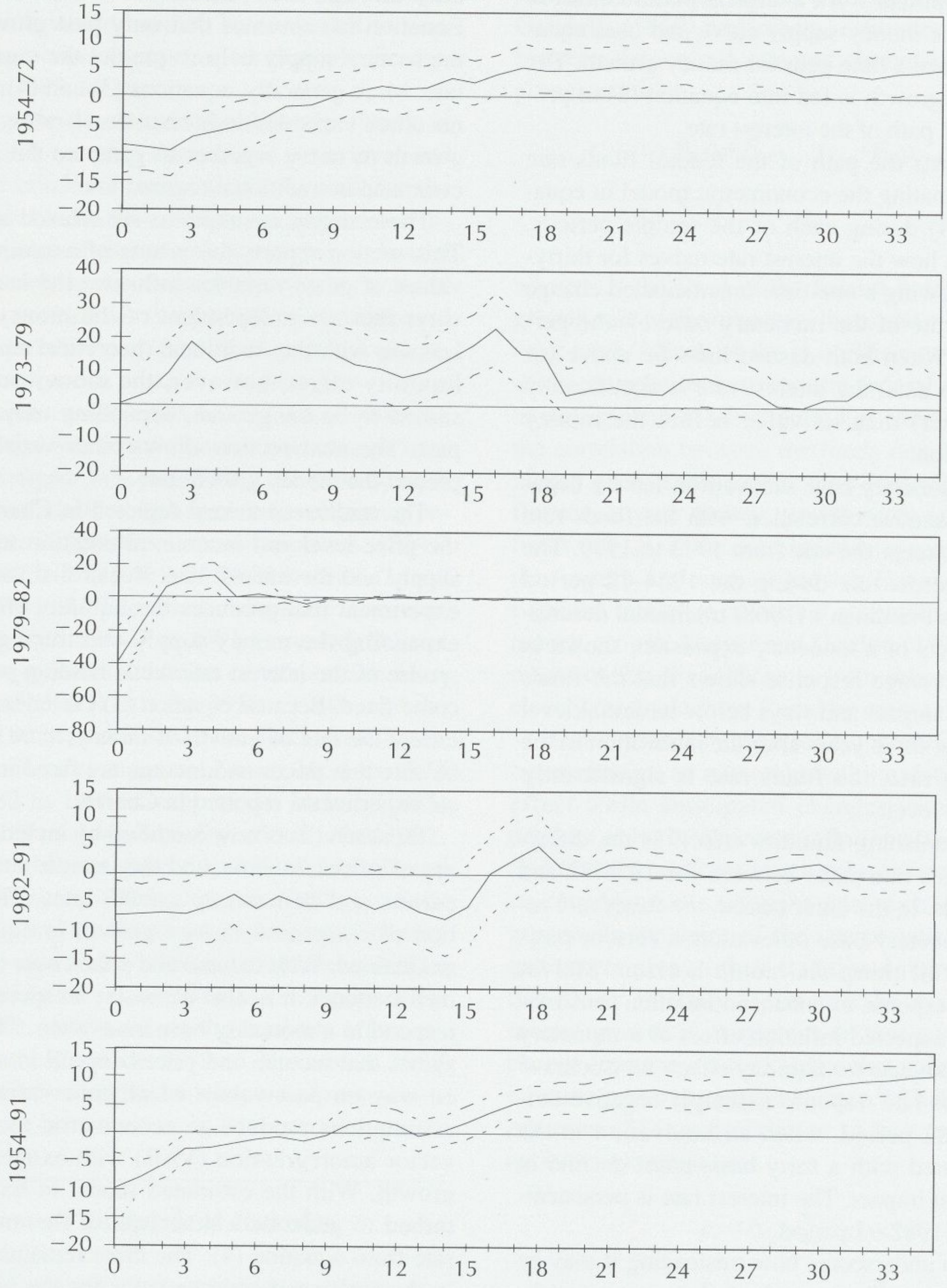
These strong assumptions are relaxed in two steps. This section reports the results of assuming that past values of other variables influence the interest rate in ways that are independent of the money supply. In keeping with the traditional theoretical analysis of the liquidity effect, however, the money supply is assumed to be exogenous, depending only on its own past. The next section allows other variables to help predict the money growth rate.

The traditional theory depicted in Chart 1 involves the price level and income, in addition to the money supply and the interest rate. Recall that the conceptual experiment that produces the liquidity effect requires expanding the money supply and tracing out the response of the interest rate while holding prices and income fixed. Because equation (3) excludes all variables except the rate of growth of money, there is no way to be sure that prices and income are fixed in the empirical experiments reported in Chart 4.

Equation (3) is now modified by including past values of prices, income, and the interest rate along with current and past money growth rates. The specification of exogenous money growth in equation (4) is maintained. With income and prices now in the econometric model, it is also necessary to specify how they respond to a monetary base innovation. The model assumes that income and prices depend in an unrestricted way on past values of all four variables. These assumptions produce an econometric model called a vector autoregression (VAR) with exogenous money growth. With the estimated model in hand ϵ_t is perturbed to generate a time path of the money growth rate from equation (4). The three remaining equations in the VAR produce time paths for the funds rate, income, and prices, using the generated path of money growth as an input to the equations.

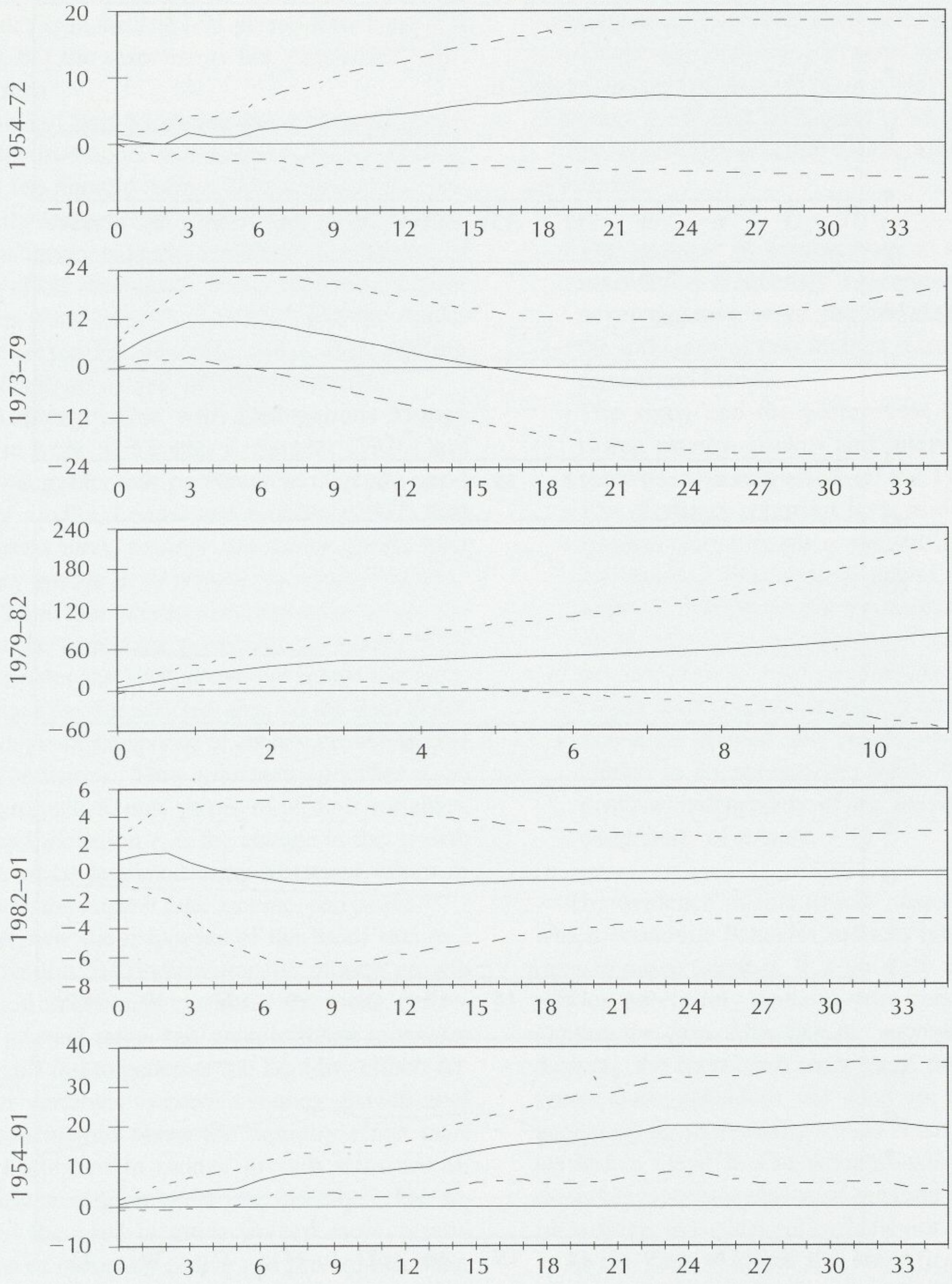
Chart 5 reports the responses of the funds rate to a 1 percent money growth innovation.[18] The contemporaneous correlation between unanticipated monetary growth and the funds rate is never negative and is

Chart 4
The Response of the Federal Funds Rate to a 1 Percent Monetary Base Innovation: Traditional Regressions with Exogenous Money Growth



The funds rate is measured in basis points. The solid line is the point estimate, and the dashed lines are significance bands (generated using the Bayesian Monte Carlo integration procedure described in Doan 1990). The interest rate regressions were estimated with the following lag lengths: 1954-72 (thirty-six lags), 1973-79 (eighteen lags), 1979-82 (six lags), 1982-91 (eighteen lags), and 1954-91 (thirty-six lags). The zero month is the contemporaneous response of the funds rate.

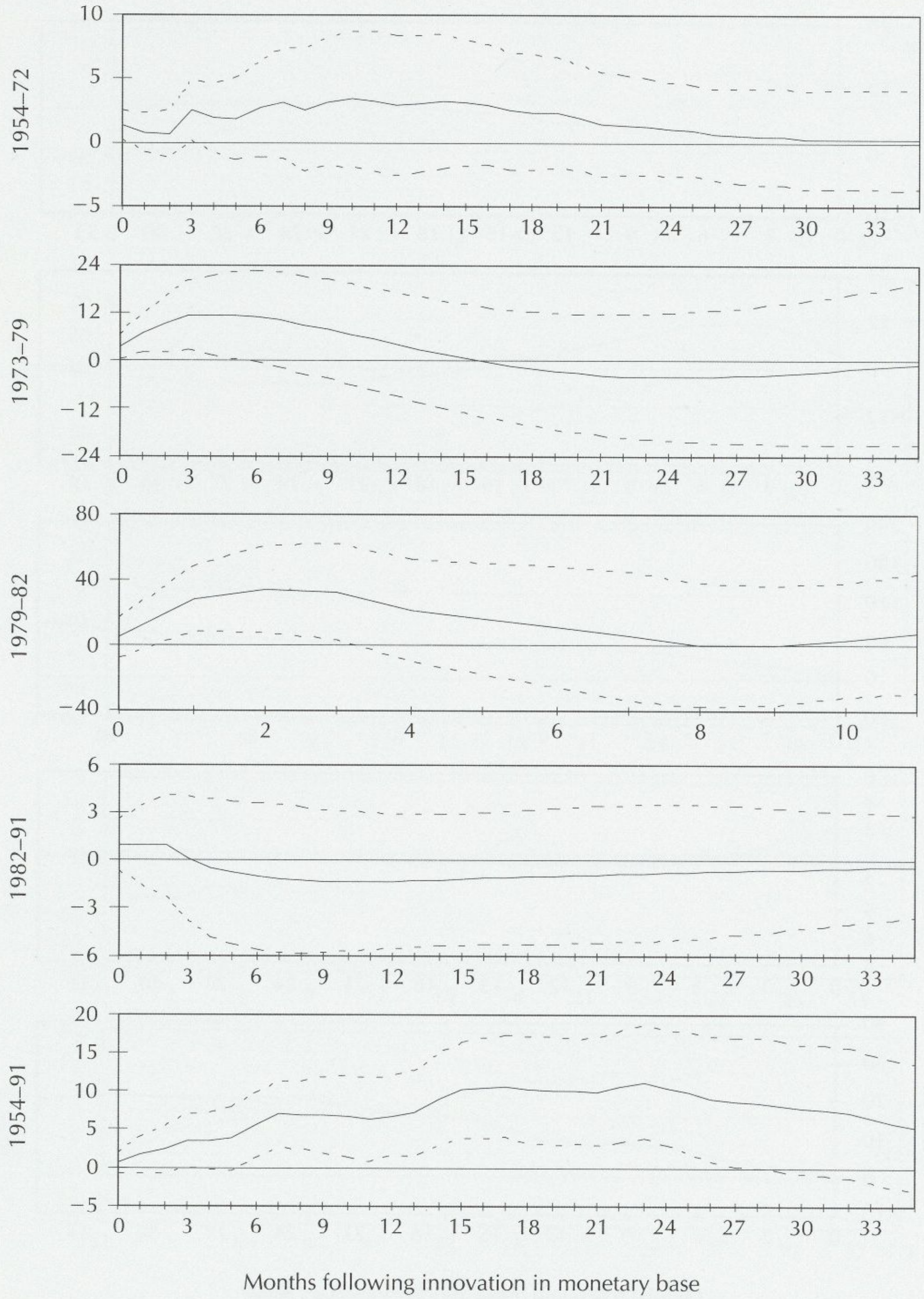
Chart 5
The Response of the Federal Funds Rate to a 1 Percent Monetary Base Innovation: Vector Autoregressions with Exogenous Money Growth



Months following innovation in monetary base

The funds rate is measured in basis points. The solid line is the point estimate, and the dashed lines are significance bands (generated using the Bayesian Monte Carlo integration procedure described in Doan 1990). The vector autoregressions were estimated with the following lag lengths: 1954-72 (twelve lags), 1973-79 (three lags), 1979-82 (three lags), 1982-91 (three lags), and 1954-91 (eighteen lags). The zero month is the contemporaneous response of the funds rate.

Chart 6
The Response of the Federal Funds Rate to a 1 Percent Monetary Base Innovation: Vector Autoregressions with Endogenous Money Growth



The funds rate is measured in basis points. The solid line is the point estimate, and the dashed lines are significance bands (generated using the Bayesian Monte Carlo integration procedure described in Doan 1990). The vector autoregressions were estimated with the following lag lengths: 1954-72 (twelve lags), 1973-79 (three lags), 1979-82 (three lags), 1982-91 (three lags), and 1954-91 (eighteen lags). The zero month is the contemporaneous response of the funds rate.

strongly positive in some subperiods. In most subperiods, the funds rate rises steadily following a money growth innovation. Surprisingly, in the period from 1979 to 1982, during which the strongest contemporaneous liquidity effect showed up in Chart 4, the funds rate response is positive. The only negative response of interest rates is in the 1982-91 period after a lag of a few months, but the response is not significantly different from zero.

The results in Chart 5 indicate that it is questionable to interpret the traditional regression results as primarily reflecting the liquidity effect. When empirical work controls for the influence of past interest rates, income, and prices, as theory suggests it should, all evidence of the liquidity effect disappears. If the traditional regression analyses were correctly specified and the results primarily reflected the liquidity effect, then holding other variables fixed should not alter the results.

Vector Autoregression with Endogenous Money Growth. The work of Thomas J. Sargent (1976) and Sims (1980) suggests that past interest rates are good predictors of money. Leeper and Gordon (1992) find that past interest rates, income, and prices jointly help predict money growth in all periods except the one from 1973 to 1979 and that interest rates and income individually tend to be important predictors of money. This section reestimates the VAR above but leaves the money growth equation unrestricted also, so the data determine the endogenous response of money growth to past economic conditions. This approach specifies Z_t in equation (2) to include past values of all four variables, so the money innovation ϵ_t is the change in the growth rate that cannot be predicted using historical values of money growth, the interest rate, income, and prices.[19]

Chart 6 reports the responses of the funds rate to a money innovation.[20] Conditioning the money growth innovation on additional variables dampens the responses of interest rates, but unanticipated monetary expansions still fail to generate the liquidity effect. Allowing other variables to predict money growth does not affect conclusions about the liquidity effect once variables in addition to money growth rates are allowed to influence the interest rate directly.[21] The results suggest the need to move toward more careful identification of monetary policy and private behavior.

Summary and Conclusions

There is broad agreement that the negative interest elasticity of money demand is the economic mechanism that produces the liquidity effect. There is also a widespread belief that the observed correlations between money growth and interest rates should be interpreted as the liquidity effect dominating the economy's short-run response to monetary policy shocks. Given this consensus, it is surprising that the data do not support explaining money/interest rate correlations entirely with the demand-side economic behavior described by Friedman (1968) and Cagan (1972) and embedded in models developed by Lucas (1990) and others.

The results of this study can be briefly summarized as follows:

- The response of interest rates to a money growth innovation frequently becomes positive and is never negative when the correlations control for the influence of past interest rates, money growth, prices, and income.
- The signs and the patterns of correlations between money growth and interest rates are not robust across subperiods of the 1954-91 sample.
- The findings reported here and in Leeper and Gordon (1992) imply a statistical rejection of the assumption that money growth is exogenous, which is critical to the traditional interpretations of the data. The assumption of exogeneity is also not sufficient to produce a negative correlation between unanticipated money and the interest rate. When the interest rate, prices, and income are included in an unrestricted VAR, the correlation is positive, independent of the assumption about the exogeneity of money.

The evidence in this article raises questions about which economic behavior induces money and interest rates to move together. It is unlikely that analyses that rely on an entirely demand-side story will be able to explain the data. Although the economic behavior underlying the traditional analysis of the liquidity effect seems quite plausible, the data are almost certainly generated by more complicated behavior than that described in Chart 1. The demand-side mechanisms are an incomplete description of the data in the absence of identifying monetary policy behavior.

In the United States the identification problem is actually more complicated than the extended example in the text suggests. Money-demand and money-supply decisions are inherently simultaneous at data frequencies of one month or longer. Demanders are choosing a quantity of the monetary base to hold as a function of the current federal funds rate, prices, and income, as well as past information. The Fed supplies the monetary base to hit a federal funds rate target during this period. Even under the assumption that the Fed does not observe current prices and income, the Fed does observe a vast array of other information that may serve effectively as proxies for current prices and income. Thus it is extremely difficult to argue on a priori grounds that there are readily available data series that shift money supply but do not shift money demand and vice versa.

By not offering up a measure of the effect on the interest rate of a given open market operation, these results may appear exceedingly negative. Unfortunately, the results accurately reflect the current state of economic knowledge about the short-run effects of monetary policy. They also lead the way toward future research by pointing out the need to go beyond simple correlations when identifying monetary policy effects. Recent work separates money-supply shocks and money-demand shocks by identifying vector autoregression models in a way that leaves the dynamics of the model unrestricted (Sims 1986, 1988; Jordi Gali 1990). Interestingly, this approach tends to find liquidity effects from identified money-supply shocks. Only by facing up to our ignorance about the effects of monetary policy will future research help resolve the uncertainty about the role of money in the economy.

Notes

1. Discussions of the liquidity effect often leave "the money supply" undefined. Throughout this article "the money supply" refers to the monetary base.
2. In addition, many researchers seem to treat the liquidity effect as a criterion of acceptability in the specification, estimation, and simulation of economic models. For example, Christiano (1991, 3) labels the negative short-run response of interest rates to a surprise monetary expansion "a basic premise guiding the implementation of monetary policy," which is an "important characteristic for a good model to have." Bryant, Holtham, and Hooper (1988) report that all but one of the dozen econometric models they study produce declines in short-term nominal interest rates following a U.S. monetary expansion. Laidler writes, "Of the literally hundreds of studies of the demand for money . . . I am aware of only three that have failed to find a significant negative relationship between the rate of interest and the demand for money" (1985, 124).
3. Roberds (1992) discusses American monetary policy behavior during this period and presents evidence on federal funds rate volatility from 1976 to 1991.
4. Similar results already exist. Mishkin (1983) fails to uncover a negative relationship between unanticipated money and interest rates. Sims (1980, 1986) and Litterman and Weiss (1985) report that unanticipated changes in the money supply are not associated with sizable short-run declines in interest rates.
5. The reasoning follows from the Fisher relationship, which states roughly that the nominal interest rate equals the real interest rate plus the expected inflation rate over the maturity of the instrument being priced. Implicit in the traditional theoretical analysis is the assumption that monetary policy cannot influence the real interest rate in the long run. See Espinosa (1991) for a different perspective on this contentious issue in monetary theory.
6. Although the conceptual experiment in Chart 1 involves the level of the money stock, empirical work frequently uses the growth rate of money. This practice is less of an inconsistency than it may appear. The liquidity effect arises from changes in the level of the money supply, while the expected inflation effect arises from changes in current and expected future growth rates of money. Of course, the level of money today can be expressed in terms of current and past growth rates and the level of money at some initial date. The connection between levels and growth rates allows the two measures to be used interchangeably. As a practical matter, the empirical results presented later in the article hold whether the money stock is in levels or growth rates.
7. To be more precise, this body of work often allows the growth rate of money today to depend on past growth rates plus the outcome of a spin of a roulette wheel today.
8. Roberds (1992) offers a clear presentation of interest rate smoothing, one well-recognized proximate goal of monetary policy.
9. These arguments draw on Sims (1987).
10. Heller (1988), former member of the Board of Governors of the Federal Reserve System, makes this point. After listing several variables whose performance could bring forth a discretionary open market operation, Heller writes, "FOMC members often differ on the relative importance of these factors" (428).
11. The Fed's behavior is couched in terms of the money supply because, even when the Fed targets the federal funds rate, it does so through open market operations that alter certain monetary entries on the Fed's balance sheet.
12. As mentioned above, this claim says nothing about having to extract analogous shocks to money demand to measure the liquidity effect.
13. In contrast, many earlier articles on the liquidity effect use broader monetary aggregates, such as M1 or M2. Because private behavior strongly influences these aggregates, the Fed cannot control them under any operating procedure and they are only loosely connected to the open market operations that the Fed conducts to achieve its target variable.

Leeper and Gordon (1991) report results that use M1 and M2 in place of the base.

14. Some studies regress the level of the interest rate against the level of the money stock (Gibson 1970b and Stokes and Neuburger 1979), some use the growth rate of money as the independent variable (Cagan 1966; Gibson 1970a; Reichenstein 1987; and Cochrane 1989), and some regress the change in interest rates against the change in money growth (Cagan and Gandolfi 1969; Cagan 1972; Gibson 1970a; and Melvin 1983). This is not an exhaustive list of studies or functional forms of the regressions that have been estimated.
15. The following lag lengths are used: 1954:7 to 1972:12 (thirty-six lags), 1973:1 to 1979:9 (eighteen lags), 1979:10 to 1982:11 (six lags), 1982:12 to 1991:11 (eighteen lags), and 1954:7 to 1991:11 (thirty-six lags). These lag lengths are consistent with those used in previous studies.
16. This specification of money growth denies any sort of purposeful monetary policy behavior. The specification is used only because it is consistent with how the literature on the liquidity effect has traditionally modeled money growth.
17. This is the thrust of Tobin's (1970) classic critique of evidence in favor of monetarism (see, for example, Friedman and Schwartz 1963a, 1963b and Friedman and Meiselman 1963).
18. These regressions estimate more coefficients than does equation (3), so the lag lengths were shortened as follows: 1954:7 to 1991:11 (eighteen lags), 1954:7 to 1972:12 (twelve lags), 1973:1 to 1979:9 (three lags), 1979:10 to 1982:11 (three lags), and 1982:12 to 1991:11 (three lags). The system for the 1979:10 to 1982:11 period includes only past interest rates and money growth. Leeper and Gordon (1991) show that the results do not change when different lag lengths are used.
19. The new money growth specification should be seen as a statistical representation of money growth rather than as a description of actual Fed behavior. Leeper and Gordon (1991) show that the results do not change when current values of income and prices are permitted to predict money growth.
20. These VARs are estimated with the same lag lengths as in the VARs with exogenous money growth.
21. A third variant on the traditional specification in equations (3) and (4) is to impose that only current and past money growth rates influence the interest rate but to allow other variables to predict money. Leeper and Gordon (1992) consider this specification and find that allowing money growth to respond to other variables is sufficient to overturn the traditional results portrayed in Chart 4.

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