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ABSTRACT

Over the last twenty-five years, a set of influential studies has placed interest rates at the heart of analyses that interpret and evaluate monetary policies. In light of this work, the Federal Reserve's recent policy of "quantitative easing," with its goal of affecting the supply of liquid assets, appears to be a radical break from standard practice. Alternatively, one could posit that the monetary aggregates, when measured properly, never lost their ability to explain aggregate fluctuations and, for this reason, represent an important omission from standard models and policy discussions. In this context, the new policy initiatives can be characterized simply as conventional attempts to increase money growth. This view is supported by evidence that superlative (Divisia) measures of money often help in forecasting movements in key macroeconomic variables. Moreover, the statistical fit of a structural vector autoregression deteriorates significantly if such measures of money are excluded when identifying monetary policy shocks. These results cast doubt on the adequacy of conventional models that focus on interest rates alone. They also highlight that all monetary disturbances have an important "quantitative" component, which is captured by movements in a properly measured monetary aggregate.

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1. INTRODUCTION

More than twenty-five years ago, Bernanke and Blinder (1988) compactly summarized the choice facing a central bank. After modifying a standard, Keynesian IS curve to account for shocks to the financial sector, their analysis reached two clear and straightforward conclusions:

> "But suppose the demand for money increases (line 2), which sends a contractionary impulse to GNP. Since this shock raises M, a monetarist central bank would contract reserves in an effort to stabilize money, which would destabilize GNP. This, of course, is the familiar Achilles heel of monetarism. Notice, however, that this same shock would make credit contract. So a central bank trying to stabilize credit would expand reserves. In this case, a credit-based policy is superior to a money-based policy.
>
> The opposite is true, however, when there are credit-demand shocks. Line 4 tells us that a contractionary (for GNP) credit-demand shock lowers the money supply but raises credit. Hence a monetarist central bank would turn expansionary, as it should, while a creditist central bank would turn contractionary, which it should not.
>
> We therefore reach a conclusion similar to that reached in discussing indicators: If money-demand shocks are more important than credit-demand shocks, then a policy of targeting credit is probably better than a policy of targeting money." (p. 438)

The authors then investigated whether the demand for money or credit was relatively more stable and found evidence to conclude that the demand for credit, especially since 1980, was more stable; the implication was that, on the basis of this evidence, monetary policy would have better success in stabilizing GNP if it stabilized credit rather than variations in money.

The question posed by Bernanke and Blinder in 1988 was important then and, in view of the large shocks to credit demand that have occurred since 2007, it still is correct to ask a similar question of central banks today: If the stabilization of nominal spending (which encompasses the Federal Reserve's dual mandate of goals for price stability and real output) is to be achieved, which intermediate targeting strategy will accomplish this most effectively? The modern literature, however, contains relatively little of this discussion. Instead, the intervening years have narrowed the focus almost entirely to interest rate rules of the type proposed by Taylor

(1993) or some alternative guide to setting the federal funds rate. The monetary aggregates have all but disappeared from the discussion.

In what follows, we briefly review the context in which the original Bernanke and Blinder paper was written and the events that led to scuttling monetary aggregates both from modern mainstream models and, by extension, from discussions of policy options. We then offer some counter-arguments to this consensus that suggest the role of the aggregates, as information variables or intermediate targets, may have been mistakenly closed. With this as backdrop, we propose that the Federal Reserve's recent "experiments" with "quantitative easing" might usefully be viewed not as a radical break from the past necessitated by the zero lower bound on the federal funds rate, but as an extension of policies that have led, systematically, to movements in monetary aggregates that have been followed, first, by movements in real GDP and, later, by movements in nominal prices. This real-world experiment illustrates both the dangers of a monetary policy strategy that focuses solely on targeting interest rates and the limitations of an intellectual framework that fails to account for the important role that always has, and still is, played by variations in the growth rate of the aggregate quantity of money.

2. HISTORICAL CONTEXT

When Bernanke and Blinder (1988) appeared, the debate about choosing money or the federal funds rate as an intermediate target was anything but closed. Only a year after this article was published, the working-paper (1989) version of Hallman, Porter, and Small (1991) outlined their influential P-star model, which linked M2 to the price level and had explicit Quantity Theory foundations. Moreover, only recently, both Meltzer (1987) and McCallum (1988) had presented monetary policy rules that used the monetary base to control variations in nominal spending directly. Conversely, the Federal Reserve officially abandoned its practice of monetary targeting in October 1982 and, since that time, has implemented monetary policy with a variety of approaches to targeting the federal funds rate. Dissension about the reliability of the signals given by the aggregates also had begun to grow, based in part on (faulty) predictions of renewed inflation in the mid-1980s that were supposed to have followed the rapid growth of M1 that had been observed. Because some of the most prominent economists had been embarrassed publicly when their warnings of accelerating inflation never materialized (see, e.g., Friedman (1984, 1985)), cracks in the empirical foundations of monetarism had been revealed; Nelson (2007, pp.162-168) and Barnett (2012, pp.107-111) offer discussions of the role that money supply measurement played in this episode.

These cracks grew larger when several key papers were published in the early 1990s. First, Friedman and Kuttner (1992) presented evidence indicating that the strong association between money and aggregate economic activity appeared to be an artifact of two decades: The 1960s and 1970s. If the estimation period for the same relationships contained data from the 1980s, the authors found that previously strong associations between money and aggregate spending were no longer significant and that the demand for money function exhibited instability. The same paper also found that money's explanatory power was replaced by variations in short-term interest rates, including the four-to-six-month commercial paper rate, the three-month Treasury bill rate, and the spread between the two. Several months later, Bernanke and Blinder (1992) reinforced these findings by examining the role of the federal funds rate in the monetary transmission mechanism. Like Friedman and Kuttner, these authors found that any role for money was minimized once the federal funds rate was introduced into the empirical framework. The conclusion was that any association money might have had with aggregate activity prior to 1980 had been seriously, and perhaps irredeemably, undermined by the financial innovations era.

The empirical evidence supporting this perspective accumulated on two fronts throughout the 1990s. One line of investigation found that previously stable demand for money functions now exhibited considerable instability and, in doing so, violated a basic condition necessary for any reliance on the monetary aggregates as intermediate targets or indicator variables. A branch of this research found consistently that variations in the federal funds rate or the commercial paper-Treasury bill rate spread both were closely linked to the cycle. In combination, the break-downs in what had been strong associations between money and nominal magnitudes and the growing body of evidence linking interest rates to aggregate activity shifted the focus of research and monetary policy to models that had the federal funds rate at their core. Taylor's (1993) influential paper reinforced this shift in emphasis by showing how well the Federal Reserve had adjusted its federal funds rate target in response to movements in output and inflation during the late 1980s and early 1990s. By the end of the decade, the mainstream macro model outlined by Clarida, Gali, and Gertler (1999) included an equation for the federal funds rate but not the aggregate quantity of money. In this "New Keynesian" model, as Eggertsson and Woodford (2003) emphasize, the thrust of monetary policy – expansionary or contractionary – gets summarized entirely by current and expected future short-term nominal interest rates.

Our first set of empirical findings suggests, however, that this conventional wisdom may have been built on the basis of results that are not entirely robust. Related arguments have been made before. For instance, Thoma and Gray (1988) point to the importance of outliers in the data from 1974 in driving the results in Friedman and Kuttner (1992) and Bernanke and Blinder (1992) that link interest rates to economic activity. In addition, both Belongia (1996) and

Hendrickson (2011) have replicated various portions of Friedman and Kuttner (1992) by doing nothing more than replacing the Federal Reserve's official simple sum measures of money with superlative (Divisia) indexes of money. After estimating the same relationships over the same sample periods with only this change, these authors found that money still shares a strong relationship with aggregate economic activity and that the demand for money function still exhibits stability. Because simple sum indexes cannot internalize pure substitution effects, as emphasized by Barnett (1980, 2012) and Belongia and Ireland (2012a), the Federal Reserve's official money supply data incorporate measurement error of unknown magnitude in their construction that will influence economic inference. Our results add to this evidence by finding that, when Divisia measures of money are included in the place of their simple sum counterparts, these quantity measures contain information and possess significant explanatory power comparable to that found in interest rates.

We derive a second set of results by incorporating Divisia measures of money into a structural vector autoregression (SVAR) similar to that developed by Leeper and Roush (2003). Our framework shows how the use of Divisia monetary aggregates allows for better measurement of the key variables, as well as a more theoretically appealing depiction of the demand for monetary services; both assist in the crucial task of disentangling money supply from money demand. We find, as do Leeper and Roush, that including measures of money in the SVAR's information set helps reduce the so-called "price puzzle," according to which an identified, contractionary monetary policy shock is associated initially with a rise in the aggregate level of prices. More important, we show that specifications that depict monetary policy as following a standard Taylor-type rule are rejected, statistically, in favor of an alternative that assigns a key role to the monetary aggregates; we find that, by contrast, restricting the policy equation to focus even more specifically on money does very little damage to the model's empirical fit. We also find, by making use of valuable new data on the Divisia aggregates provided by the Center for Financial Stability and described by Barnett, Liu, Mattson, and van den Noort (2013), that our results are robust to the level of monetary aggregation. Finally, we use the structural VAR to gauge the effects of Federal Reserve policy in the years leading up to and immediately following the financial crisis of 2007 and 2008; strikingly, these results corroborate Barnett's (2012) arguments that monetary instability looms as an important factor in recent US monetary history. Our results also provide a rationale for at least some aspects of the Fed's moves towards "quantitative easing."

Throughout our analysis and discussion, we take care to avoid dogmatic interpretations of our results. Our message certainly is not that interest rates play no role in the process through which monetary policy actions are transmitted through the economy. Instead, we wish to emphasize the important disconnect that appears between our empirical results (as well as those of Leeper and Roush (2003)), pointing to a significant role for money, and the recent theoretical literature, which focuses largely if not exclusively on interest rates instead. Understanding where the information content of the monetary aggregates comes from, and how it can be efficiently exploited in the design of monetary policy, remains as important today as it was a quarter century ago, when Bernanke and Blinder's (1988) work appeared.

3. THE INFORMATION CONTENT OF INTEREST RATES AND MONEY

Bernanke and Blinder (1992) examined the relative information content of money and interest rates in explaining variations in assorted measures of real activity in the context of an equation of this form:

$$Y_t = \alpha + \sum_{i=1}^{6} \lambda_i Y_{t-i} + \sum_{i=1}^{6} \beta_i X_{t-i} + \sum_{i=1}^{6} \gamma_i P_{t-i} + e_t, \quad (1)$$

where Y_t is one of several measures of real activity to be explained, X_t is a measure of monetary policy, P_t is the Consumer Price Index, which adjusts each estimation for any effects from changes in the general price level, α and λ_i, β_i, and γ_i, $i = 1,2,\ldots,6$, are regression coefficients, and six lags of each monthly variable appear on the right-hand side. Their measures of real activity ranged from capacity utilization and housing starts to several measures of labor market activity and retail sales. Bernanke and Blinder used the Federal Reserve's simple sum measures of M1 and M2 as well as the federal funds rate, the Treasury bill rate, and the 30-year Treasury bond rate as measures of "X" in the equation above.

In the interest of space and because our research question is directed to the effects of measurement on inferences about money's effect on economic activity and to the relative influences of monetary aggregates and the funds rate on real activity, we report here only a partial set of replications and extensions of the results from the original Bernanke and Blinder paper. In particular, we limit our work to estimations with simple sum measures of M1 and M2 and the funds rate and add Divisia measures of M1, M2 and MZM (M2, less small time deposits, plus Institution-only Money Market Mutual Funds) as described by Barnett, Liu, Mattson, and van den Noort (2013). As discussed by Motley (1988), the MZM aggregate limits itself to items that are immediately convertible, without penalty, to some form of a medium of exchange.

To help foreshadow the results we report below, figure 1 compares the behavior of simple sum and Divisia measures of M2. The top panel shows year-over-year growth rates in both aggregates, to highlight cyclical movements while smoothing out higher frequency noise; the bottom panel plots the difference between these series. Statistically, the difference variable shown in the bottom panel has a nonzero mean equal to −1.25, sizable standard deviation and first-order autocorrelation of 2.57 and 0.989, and negative skewness −1.07. Moreover, a standard Augmented Dickey-Fuller test on the difference variable indicates that this series is not stationary (−1.95 against a 0.05 critical value of −2.87). This result implies that a central bank attempting to achieve some nominal target by monitoring the growth rate of money eventually will drift off path by monitoring sum M2 rather than its Divisia counterpart.

A visual comparison of the simple sum and Divisia growth rates shown in figure 1 points to the episode of disinflation and financial deregulation of the early 1980s as the principal source of negative skewness, noted above, in the difference series. During this period, the Divisia measure provides the stronger and more accurate signal of monetary tightness; the simple sum series dramatically overstates the true rate of money growth by failing to internalize the effects of portfolio shifts out of traditional, noninterest-bearing monetary assets and into newly-created, but somewhat less liquid, interest-earning accounts such as monetary market mutual funds and deposit accounts. Friedman's (1984, 1985) predictions of a return to higher inflation during this episode were based, primarily, on his observations of robust growth in the simple-sum monetary aggregates; hence, these graphs support Barnett's (2012) contention that Friedman might have reached different conclusions had he monitored data on the Divisia aggregates instead.

The series in figure 1 also show that, especially over the period since 1985, Divisia M2 has grown at a rate that consistently exceeds the growth rate of the simple-sum M2 during periods of falling interest rates, particularly during the early stages of the 1990-1991, 2001, and 2007-2009 recessions; conversely, Divisia M2 growth tends to fall short of simple-sum growth during periods of rising interest rates. Belongia and Ireland (2012a) use a New Keynesian model to show, theoretically, how liquidity effects such as these, manifesting themselves in an inverse relationship between money growth and interest rates, show up much more clearly in Divisia monetary aggregates than in their simple-sum counterparts. Consistent with these theoretical results and the reduced-form correlations implied by the series shown in figure 1, the SVAR we develop and estimate below associates monetary policy easings that lower nominal interest rates with strongly accelerating rates of Divisia money growth and, conversely, monetary tightenings that raise nominal interest rates with sharp contractions in Divisia money growth.

With six measures of how monetary policy might influence alternative indicators of real activity, we were left with choices about sample periods for the model's estimation. In a perfect world, we would have been able to replicate all of the samples in the original Bernanke and Blinder work but this is not possible because the Divisia data originate in January 1967 and the first sample for the original study began in 1959. We can terminate our samples, however, in 1979.12 and 1989.12 as was the case in the original work and, in the spirit of examining the robustness of the results, we can re-estimate the same relationships on data drawn completely beyond the terminal date of the original study. In all, Bernanke and Blinder's causality tests are repeated across six samples and the results are reported in tables 1 through 6; the entries in the tables are marginal significance levels. In each case, we are interested in two questions. First, do differences in measurement between simple sum and Divisia aggregation indicate important cases where money, when measured by one of the Federal Reserve's official aggregates, shows no effect on economic activity, yet is linked to economic activity by a Divisia measure? Second, are Divisia measures of money and the funds rate linked to economic activity in different ways across alternative measures of economic activity and sample periods? We now turn to the results for answers to these questions.

The first two tables report results for samples that resemble most closely those employed in the original Bernanke and Blinder study; although the beginning date now is 1967.01, the terminal dates are 1979.09 (to coincide with the beginning of the Federal Reserve's announced plan to target money growth) and 1989.12. As noted above, each entry in these tables corresponds to the significance level for the statistic testing the hypothesis that all lags of the monetary variable "X" can be excluded from the regression equation (1); smaller values, therefore, point to a stronger role for the monetary policy measure. The results both confirm and reject the findings of original work in several ways. First, as in the original paper, the funds rate is shown to have a significant effect on all measures of economic activity but two. Unlike the original paper when M2 affected only retail sales and M1 had no marginal significance on any variable, the results here show that simple sum measures of money, especially M2, have effects on multiple measures of economic activity. It is unknown whether these differing results can be attributed to differences in vintages of data, a change in the starting date for the estimation, or issues associated with replicating the original work as discussed in Thoma and Gray (1998, footnote 2).

With respect to issues of measurement, however, the tables also reveal some important consequences. In table 1, for the sample that terminates prior to the financial innovations era, there is little to distinguish, for example, sum and Divisia M1: Both have significant effects on personal income, retail sales, and durable goods orders. In the case of M2, the sum measure is significantly associated with four measures of real activity and the Divisia measure three, with a 0.06 significance level on a fourth variable. In table 2, however, which includes a sample that terminates at 1989.12, the results reveal what was at stake when financial innovations induced substitutions among components of a monetary aggregate and those substitutions would have generated aberrant behavior in an index that could not internalize pure substitution effects. Now, rather than diminishing the strength of any association between money and variations in real activity, the last two rows of table 2 indicate that that Divisia M2 and MZM are related to eight of the nine measures. And, while the funds rate is linked to all of the nine measures, these results hardly can be interpreted as evidence that money lost its ability to explain aggregate fluctuations after the 1970s. In fact, to emphasize the thrust of this paper, the case that money is unrelated to aggregate fluctuations depends entirely on the results in the table's first column where the Federal Reserve's simple sum measure of M1 fails to help forecast movements in all nine measures of real activity. Instead, as a general impression, the results in Table 2 for both broad Divisia aggregates are at odds with the conclusions of the original Bernanke and Blinder paper and, for that matter, work in the spirit of Friedman and Kuttner as well: Monetary aggregates -- when measured properly -- exhibit significant associations with a majority of the indicators of business cycle activity.

Because the first two samples include 1974, a period Thoma and Gray (1998) found to include several interest rate outliers that can influence standard inference, table 3 reports results using an estimation period that covers 1975.04 through 1989.12. Although the federal funds rate remains associated with all nine measures of economic activity over this sample, both simple sum measures of money now appear related to four out of the nine indicators. The effects of money become stronger still when the Divisia aggregates are used: Divisia M1 is significantly associated with four variables, Divisia M2 with five, and Divisia MZM with six. Particularly when the issue of measurement is considered, therefore, these results are sufficient to give one pause before abandoning the monetary aggregates as indicators of monetary policy.

Table 4 reports results for a sample drawn from data completely beyond the publication of the original study, 1990.01 through 2007.12, and they offer more evidence on the importance of measurement. In this case, simple sum and Divisia M1 are both related to four of the variables, while simple sum and Divisia M2 and Divisia MZM are each related to three. The federal funds rate significantly influences five of the nine variables but, with the exception of the unemployment rate, to different measures of activity than those closely connected to the monetary aggregates. Thus, if one is interested in the question, “Is money or the funds rate more closely linked to economic activity?” the results in Table 4 indicate that it matters not only how the quantity of money is measured but also on the metric by which economic activity is measured. Likewise, table 5 reports results from estimations across the 1975.04 - 2007.12 period, which abstracts from the interest rate outlier issue and ends prior to the beginning of the most recent economic downturn. Again, the funds rate relates significantly to many of the variables, but so do the measures of money, particularly, in this case, Divisia M1 and MZM.

Finally, table 6 shows results from the period from 2000.01 through 2013.12, which includes the financial crisis and most recent recession, during and after which the Federal Reserve used several rounds of large-scale asset purchases -- “quantitative easing” -- in an effort to provide further monetary stimulus while its federal funds rate target was constrained by the zero lower bound. Notably, all six measures of monetary policy appear significantly related to subsequent movements in real consumption spending and housing starts, variables tied most directly to the crisis and its effects on American families. Throughout this latest episode, however, the Divisia measures of money appear most closely linked to movements in real economic activity, compared not only to the corresponding simple sum measures but also to the federal funds rate, which is significant in only four of nine cases.

The general message -- that the loss of explanatory power for the monetary aggregates can be traced to the continued use of the Fed's flawed simple sum aggregation methods -- seems to be verified by the results in this table and the tables that precede it. These results also present, as in Belongia (1996) and Hendrickson (2011), additional cases in which an earlier rejection of money's influence can be reversed when the Federal Reserve's simple sum aggregates are replaced by Divisia aggregates in the same experiment. Over all, there is no evidence in these non-nested tests to conclude that the funds rate can be preferred to money -- or vice versa -- as an indicator or potential intermediate target for the conduct of monetary policy.

4. MEASURING MONETARY POLICY

To dig deeper into the sources of the links between money, interest rates, output, and prices we follow Leeper and Roush (2003), and build a structural vector autoregressive model for these same variables. As a first step, we move from a monthly to a quarterly frequency for the data, which allows us to use real GDP as our measure of aggregate output Y_t and the GDP deflator as our measure of the price level P_t. We use the federal funds rate as a measure of the short-term nominal interest rate R_t and one of the Divisia monetary aggregates to measure the flow of monetary services M_t.

To this list of variables we add two more. First, to assist in disentangling shocks to money supply from those to money demand, we use the user-cost measure U_t, also provided by Barnett, Liu, Mattson, and van den Noort (2013), that is the price dual to the Divisia monetary aggregate M_t. Second, to mitigate the so-called "price puzzle" that associates an exogenous monetary tightening with an initial rise instead of fall in the aggregate price level, we follow the now-standard practice, first suggested by Sims (1992), and include a measure of commodity prices PC_t -- the CRB/BLS spot index now compiled by the Commodity Research Bureau -- in the VAR. The beginning of the quarterly sample period, 1967.1, is dictated once again by the availability of the monetary statistics. To obtain our benchmark results, we end the sample after 2007.4 to avoid potential distortions associated with the most recent, severe recession; but later, we also consider results that obtain when the sample is extended through 2013.4. Again following conventions throughout the literature on structural VARs, output, prices, money, and commodity prices enter the model in log-levels, while the federal funds rate and the Divisia user-cost measures enter as decimals and in annualized terms, i.e., a federal funds rate quoted as 5 percent on an annualized basis enters the dataset with a reading of R_t equal to 0.05.

Stacking the variables at each date into the 6x1 vector

$$X_t = [P_t \quad Y_t \quad CP_t \quad R_t \quad M_t \quad U_t]', \qquad (2)$$

the structural model takes the form

$$X_t = \mu + \sum_{j=1}^{q} \Phi_j X_{t-j} + B\varepsilon_t, \qquad (3)$$

where μ is a 6x1 vector of coefficients, each Φ_j, j = 1,2,…,q, is a 6x6 matrix of coefficients, B is a 6x6 matrix of coefficients, and ε_t is a 6x1 vector of serially and mutually uncorrelated structural disturbances, each following the standard normal distribution.

The reduced form associated with (3) is

$$X_t = \mu + \sum_{j=1}^{q} \Phi_j X_{t-j} + x_t, \qquad (4)$$

where the 6x1 vector of zero-mean disturbances

$$x_t = [p_t \quad y_t \quad cp_t \quad r_t \quad m_t \quad u_t]' \qquad (5)$$

is such that $Ex_t x_t' = \Sigma$.

Comparing (3) and (4) reveals that the structural and reduced-form disturbances are linked via

$$Ax_t = \varepsilon_t \tag{6}$$

where $A = B^{-1}$ and $BB' = \Sigma.$ Since the covariance matrix Σ for the reduced-form innovations contains only 21 distinct elements, at least 15 restrictions must be imposed on the elements of the matrix B or its inverse A in order to identify the structural disturbances from the information communicated by the reduced form.

A common approach to solving this identification problem requires A to be lower triangular. If the fourth element of the vector ε_t is interpreted as a monetary policy shock, this identification scheme assumes that the aggregate price level, output, and commodity prices respond with a lag to monetary policy actions, and that the Federal Reserve adjusts the federal funds rate contemporaneously in response to movements in the these same three variables but ignores the Divisia monetary aggregates and their user costs. Although recursive schemes like this one are based on assumptions about the timing of the responses of one variable to movements in the others, in this case one might also interpret the fourth line in the vector of equations from (6),

$$a_{41}p_t + a_{42}y_t + a_{43}cp_t + a_{44}r_t = \varepsilon_t^{mp}, \tag{7}$$

as an expanded version of the Taylor rule that includes commodity prices as well as GDP and the GDP deflator among the variables that influence the Federal Reserve's setting for its federal funds rate target. Note, however, that this Taylor rule serves only to capture the contemporaneous co-movement between the variables in (7); interest rate smoothing, and any other systematic responses of Federal Reserve policy to lagged data, will be reflected in the autoregressive coefficients in both (3) and (4). Likewise, the fifth line in (6),

$$a_{51}p_t + a_{52}y_t + a_{53}cp_t + a_{54}r_t + a_{55}m_t = \varepsilon_t^{md} \tag{8}$$

might be interpreted as a flexibly-specified money demand equation, linking the demand for monetary services to the aggregate price level, aggregate output, and the short-term nominal interest rate, with the commodity-price variable entering as well.

An alternative approach to identification, followed by Leeper and Roush (2003), imposes restrictions in (6) so as to allow the money supply to enter into the description of the monetary policy rule and to provide a more tightly-specified and theoretically-consistent description of money demand. Leeper and Roush conduct their empirical analysis using the Federal Reserve's simple sum M2 measure of the money supply; here, we modify and extend their approach to apply to Divisia measures of money instead. Our benchmark non-recursive model parameterizes the matrix A as

$$A = \begin{pmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & 0 & a_{44} & a_{45} & 0 \\ -a_{55} & a_{52} & 0 & 0 & a_{55} & a_{56} \\ -a_{65} & 0 & 0 & a_{64} & a_{65} & a_{66} \end{pmatrix}. \tag{9}$$

Only 19 free parameters enter into (9), implying that the model satisfies the necessary conditions for recovering the structural disturbances in ε_t from the reduced-form innovations x_t via (6). The first two rows in (9) indicate that in this specification, as in the recursive model described above, the price level and aggregate output are assumed to respond sluggishly, with a lag, to monetary disturbances. The absence of zero restrictions in the third row, however, reflects our preference for modeling commodity prices as an "information variable," responding immediately to all of the shocks that hit the economy.

Row four of (9) continues to describe a generalized Taylor rule, but one in which the supply of monetary services, as opposed to commodity prices, enters as an additional variable:

$$a_{41}p_t + a_{42}y_t + a_{44}r_t + a_{45}m_t = \varepsilon_t^{mp}, \tag{10}$$

where ε_t^{mp} represents the identified monetary policy shock. Ireland (2001) embeds a monetary policy of this general form into a New Keynesian model. One interpretation of this rule is that it depicts the Federal Reserve as adjusting its federal funds rate target in response to changes in the money supply, as well as in response to movements in aggregate prices and output. An alternative interpretation is that (10) describes Federal Reserve policy actions as impacting simultaneously on both interest rates and the money supply. Simultaneity of this kind will arise, quite naturally, even when Federal Reserve officials themselves pay no explicit attention to simple sum or Divisia monetary aggregates, if, for example, the open market operations they conduct to implement changes in their federal funds rate target also have implications for the behavior of the monetary aggregates, which then turn out to be important for describing the effects that those policy actions have on the economy. With monetary services now appearing in the policy rule, it is worth recalling that Taylor's (1979) original specification was based on money rather than interest rates; our rule in (10), therefore, combines elements from both this earlier specification and Taylor's (1993) now much more celebrated rule for the funds rate.

Row five, meanwhile, links the demand for real monetary services to aggregate output as a scale variable and to the user cost, or price dual, associated with the Divisia quantity aggregate:

$$a_{52}y_t + a_{55}(m_t - p_t) + a_{56}u_t = \varepsilon_t^{md}. \tag{11}$$

Belongia (2006) discusses why money demand relationships of this form are more coherent than more commonly-used specifications, like (8), that use a nominal interest rate in its place. The reason for this preferred specification is that economic aggregation theory provides not only a guide to measuring the quantity of money more accurately, but it also provides, in the dual to the quantity measure, the true "price" of monetary services.

Finally, row six of (9),

$$a_{64}r_t + a_{65}(m_t - p_t) + a_{66}u_t = \varepsilon_t^{ms} \tag{12}$$

summarizes the behavior of the private financial institutions that, together with the Federal Reserve, create liquid assets that provide households and firms with monetary services. Belongia and Ireland (2012a) and Ireland (2012) model this behavior in more detail, to show how an increase in the federal funds rate, by increasing the cost at which banks acquire funds, gets passed along to the consumers of monetary services in the form of a higher user cost; (12) adds the level of real monetary services created as well, to allow for the possibility that banks' costs may rise in the short run as they expand the scale of their operations. Thus, in (12), ε_t^{ms} represents a shock to the monetary system that makes it more difficult and expensive for private financial institutions to create liquid assets.

Compared to the recursive identification scheme described initially, the non-recursive specification in (9) at once provides a more detailed and theoretically-motivated description of the banks that supply monetary assets and the nonbank public that demands those same assets. In addition, (9) permits the money supply to enter into the description of Federal Reserve policy, broadening the more conventional view that focuses on interest rates alone. In fact, (9) also allows us to assess the adequacy of this conventional view by comparing the empirical fit of our benchmark model to that of two more restrictive alternatives. In particular, when $a_{45} = 0$ is imposed in (9), (10) collapses to a standard Taylor rule for adjusting the federal funds rate in response to movements in aggregate prices and output. On the other hand, when $a_{41} = 0$ and $a_{42} = 0$ are imposed instead, we obtain via (10) Leeper and Roush's (2003) preferred specification, which places money much closer to center stage by identifying monetary policy shocks based solely on the interplay between the money supply and interest rates; Leeper and Zha (2003) and Sims and Zha (2006) also incorporate money-interest rate rules of this simple form into structural vector autoregressive models.

Since none of our alternative identification strategies imposes any restrictions on the parameters in the vector μ of constant terms or the matrices Φ_j, j = 1,2,…,q, of autoregressive coefficients, these can be estimated efficiently by applying ordinary least squares to each equation in the reduced form (4). For the recursive identification scheme in which the matrix A is simply required to be lower-triangular, the usual approach is followed, in which the matrix B in (3) is obtained through the Cholesky factorization of the covariance matrix Σ of the reduced-form innovations. For the non-recursive system (9) and its two more highly constrained variants, the non-zero elements of A are estimated via maximum likelihood as described by Hamilton (1994, Ch.11, pp.331-332). Throughout, the parameter q is set equal to 4, implying that one year of quarterly lags appear in the autoregression.

Table 7 summarizes the results from estimating the vector autoregression under each of the four identification schemes: the recursive model, the structural model (9), and the two more highly constrained versions of (9) just described. As noted above, the quarterly sample period in each case begins in 1967.1 and runs through 2007.4. And while table 7 focuses on results obtained with Divisia measures at the same three levels of aggregation -- M1, M2, and MZM -- used above to extend Bernanke and Blinder's (1992) analysis, additional tables from the appendix to Belongia and Ireland (2012b) report the full range of results derived with all of the other Divisia quantity and user-cost series provided by Barnett, Liu, Mattson, and van den Noort

(2013) at the Center for Financial Stability and as well as those reported by Anderson and Jones (2011) at the St. Louis Federal Reserve Bank.

To help prevent readers from getting lost in a forest of numbers, table 7 displays estimates of the monetary policy and money demand equations (7) and (8) for the recursive model and the monetary policy, money demand, and monetary system equations (10)-(12) for the non-recursive models. And to assist in their interpretations, each of these equations is renormalized to isolate, with a unitary coefficient, the interest rate on the left-hand side of the monetary policy equation, real monetary services on the left-hand side of the money demand equation, and the user cost of the monetary aggregate on the left-hand side of the monetary services equation. In this way, across all specifications and levels of monetary aggregation, the estimated coefficients can be seen at a glance to have, with few exceptions, the "correct" signs.

In particular, the Taylor-type monetary policy rules show the Federal Reserve increasing the federal funds rate in response to upward movements in output and prices, while the most parsimonious money-interest rate rule associates a contractionary monetary policy shock, that is, a positive realization for ε_t^{mp}, as one that simultaneously decreases the money supply and increases the funds rate. The money demand equations draw positive relationships between real money services and output as the scale variable and negative relationships between real money and the associated opportunity cost variable, be it the interest rate in the recursive model or the Divisia price dual in the non-recursive frameworks. And in each of the non-recursive models, the estimates of (12) show how the private monetary system passes increases in the federal funds rate along to consumers of monetary services in the form of higher user costs; these estimates also draw a positive association between real monetary services and the user costs, consistent with our interpretation of this relationship as a "supply curve" for monetary services.

Compared to the most flexible non-recursive model that includes the monetary aggregate together with output and prices in the monetary policy equation (10), the version that reverts to a more conventional Taylor rule by excluding money imposes a single constraint on the model. Therefore, this restriction can be tested by comparing two times the difference between the values of maximized log-likelihood functions across the two specifications to the critical values implied by a chi-squared distribution with one degree of freedom. Likewise, the restrictions that exclude prices and output so that money and interest rates alone appear in (10) can be tested by comparing two times the difference in log-likelihoods to the critical values of a chi-squared distribution with two degrees of freedom. Quite strikingly, across all three levels of monetary aggregation, the constraint excluding money from the monetary policy rule is rejected at the 99 percent confidence level while, in the meantime, the constraints excluding prices and output from the policy rule is imposed without any significant deterioration in the model's statistical fit. As a matter of fact, the constraints imposed by the model with the most parsimonious money-interest rate rule cannot be rejected, even when the fit of this model is compared to the most flexible, recursive specification.

This first set of results reinforces those presented by Leeper and Roush (2003) and casts doubt on the adequacy of conventional descriptions of monetary policy that focus on interest rates alone. These results also join with those from Belongia (1996) and Hendrickson (2011) by suggesting that perennial debates about the "right" level of monetary aggregation, like several other "unsolved problems" in monetary economics, reflect more than any other factor an unfortunate reliance on simple sum aggregates in previous empirical work. So long as one accepts Barnett's (1980) argument that economic aggregation theory ought to be applied to measure the aggregate supply of monetary services just as it is applied to measure GDP, industrial production, or any other index of macroeconomic activity, one remains free to choose any monetary aggregate from M1 through MZM in drawing the main message from table 7: that money does seem to matter, importantly, in describing the effects of Federal Reserve policy.

Figure 2, meanwhile, reveals another problem that emerges from the recursive specification and, as well, from the constrained version of the non-recursive model that also excludes money from the monetary policy rule. This figure displays impulse responses of the price level and the federal funds rate to monetary policy shocks, as identified by each of our four alternative strategies. The figure shows the results obtained using the Divisia MZM index of monetary services, but once again similar findings emerge when any of the other Divisia aggregates is employed instead. Even though the commodity price variable is included in all of the models, and even though the recursive model allows commodity prices to enter into the monetary policy equation (7), this specification still gives rise to a noticeable price puzzle. Here, as in Leeper and Roush (2003), including money in the policy rule helps minimize the rise in prices that follows a contractionary policy shock. And strikingly, here, the price puzzle is greatly magnified in the third row of figure 2, when money is excluded from the Taylor-type interest rate rule, but is minimized in the last row, which uses the simplest money-interest rate rule instead. In this last case, as well, the larger disinflationary effects shown in the left-hand column are associated with the smaller rise in the interest rate shown on the right.

All of these results provide reasons to prefer our most parsimonious description of a monetary policy shock as one that leads to a contraction in the quantity of money and a simultaneous "liquidity effect" on interest rates. This specification cannot be rejected in favor of a more flexible alternative that includes prices and output in the policy rule and also produces identified monetary policy shocks that most reliably associate tighter policy with falling prices.

Figure 3, therefore, goes on to plot the impulse responses of output, prices, interest rates, and the quantity and user cost indexes for money to all three of the structural disturbances appearing in equations (10)-(12) -- to monetary policy, to money demand, and to the private financial sector -- implied by the constrained, non-recursive model with the money-interest rate rule. Once more, the results shown use Divisia MZM as the measure of money, though very similar results obtain at all other levels of aggregation. The first column of figure 3 reveals that the fall in prices and rise in the interest rate shown in figure 2 that follow an identified monetary policy shock get accompanied by persistent declines in real GDP and the quantity of money. The increase in the federal funds rate works, as well, to increase the user cost of money; Belongia and Ireland (2006) show that, through inflation-tax effects, a response in the own-price of money of exactly this kind transmits monetary policy shocks to output even in a model with completely flexible prices and wages.

The center column of figure 3 shows impulse responses to money demand shocks. The fall in output and rise in the interest rate associated with a shock that, on impact, increases the demand for monetary services are consistent with theory. And while the increase in the price level is counterintuitive, Leeper and Roush (2003) present an example where aggregate prices do rise following a positive shock to money demand. Their example is based on Ireland's (2001) version of the New Keynesian model in which the monetary policy rule also incorporates money as well as the interest rate. More difficult to explain is why, after the initial increase reflecting the shock itself, the quantity of monetary services falls persistently in figure's fourth row; this finding calls for a more detailed investigation of money demand dynamics using the newly-available series on the Divisia aggregates.

The right-hand column in figure 3 shows that a positive realization of the shock ε_t^{ms} that enters into equation (12) describing the behavior of the private financial sector generates a small initial decline in output and a much larger and more persistent decrease in prices. A persistent fall in the nominal interest rate, perhaps reflecting a deliberate, systematic monetary policy response to the financial-sector disturbance, allows the user cost of money to decline and reverse the initial decline in the quantity of monetary services. The panels in figure 4 examine, in various ways, the same model's interpretation of US monetary policy over the sample period. The top panel simply plots the realizations of the monetary policy shock ε_t^{mp}; since (3) normalizes each structural disturbance to have a standard deviation of one, the graph's scale conveniently measures the size of each realized shock in standard deviations. Reassuringly, a series of large contractionary (positive) monetary policy shocks stand out during the period beginning in the fourth quarter of 1979 and continuing through the first quarter of 1982. Elsewhere in the sample, strings of large expansionary (negative) shocks appear from 1973.4 through 1974.4 and over an even longer period of time from 2001.1 through 2004.2.

The bottom two panels of figure 4 show how the serially uncorrelated monetary policy shocks are translated, via the model's autoregressive structure, into persistent movements, first in output and then, with a lag, aggregate prices; Laidler (1997, pp.1217-1219) describes how dynamics like those shown here, in figure 4, and previously, in figure 3, are consistent with "buffer-stock" models of individuals' money demand. Each of the graphs in these two panels plots the percentage-point difference between the actual level of output or the aggregate price level and the level of the same variable implied by the model when the all of estimated historical shocks except the monetary policy shocks are fed through (3). Therefore, each panel shows how much higher or lower output or prices actually were at each date, compared the levels that would have prevailed, counterfactually, in the absence of monetary policy shocks.

The bottom panel of figure 4 highlights, in particular, how accommodative monetary policy shocks worked to increase prices by a total of 3 percentage points in the late 1970s and early 1980s. Interestingly, while the contractionary shocks in the early 1980s worked to halt temporarily this upward movement, the cumulative effect of monetary policy shocks contributed to renewed price pressures in the late 1980s and early 1990s. Monetary policy was disinflationary throughout the 1990s, but the series of expansionary shocks realized during and after the 2001 recession contributed to rising prices starting in 2002.4 and continuing through 2005.4. Of course, the swings in prices shown in figure 4 represent only a fraction of those observed over the entire sample period, indicating that our structural VAR, like those estimated previously by Leeper and Roush (2003), Primiceri (2005), and Sims and Zha (2006), attributes the bulk of inflation's rise and fall before and after 1980 not to monetary policy shocks but instead to the Federal Reserve's systematic response to other shocks that hit the economy.

Finally, figure 5 displays the model's implications when it is re-estimated with data running through 2013.4, still using the Divisia MZM aggregate and our preferred money-interest rate rule. To focus on monetary policy and its effects in the period just before, during, and after the financial crisis and severe recession, the series in the graphs begin in 2000.1, even though the data used to estimate the model continue to run all the way back to 1967.1. Strikingly, the monetary policy shocks shown in the top panel are largely contractionary from 2008.3 through 2010.2, consistent with findings from previous analyses by Hetzel (2009), Ireland (2011), Tatom (2011), and Barnett (2012), all of which point to overly restrictive monetary policy as, though perhaps not the principal cause of the "great recession," at least an important factor contributing to its length and severity.

Figure 6 helps in tracing these implications of the model back to original time series for interest rates and money. The top panel shows how the Federal Reserve lowered its federal funds rate target to a range between 0 and 0.25 percentage points in late 2008, where it has remained ever since. By itself, this unprecedented policy action has been popularly interpreted as indicating that an extremely accommodative monetary policy has helped counteract the effects of the financial crisis on output both during and since the recession that began in 2007. The statistical results presented here, however, tell a much more detailed and nuanced story. Both the Granger causality test statistics shown in table 6, which show strong forecasting power of the Divisia monetary aggregates for various measures of real activity, and the structural VAR, which depicts monetary policy actions as having effects on both interest rates and those same monetary aggregates, call special attention to the bottom panel of figure 6: For the period running from 2009.4 through 2010.2 the money stock displays -- even more severe than a deceleration in its rate of growth -- a sustained decline in its level.

In general, therefore, the dynamics shown in figures 5 and 6 remind us of one of the principal lessons that Friedman and Schwartz (1963) drew from their famous analysis of the Great Depression of the 1930s, namely, that during a banking or financial crisis the demand for highly liquid assets may require a massive expansion of bank reserves simply to prevent broader measures of the money stock from declining. More specifically, the pattern of monetary shocks shown in figure 5 and the behavior of the money supply shown in figure 6 suggest strongly that the Federal Reserve pulled back too much, too soon, when it suspended its policies of quantitative easing during 2010.

On the other hand, the monetary shocks shown in figure 5 become expansionary from 2010.3 through 2011.3, and the money stock shown in figure 6 resumes its growth at the same time. Our model, which assigns a key role to money in the policy rule, interprets every episode of monetary easing as "quantitative easing" by associating them with increases in money growth and not simply declines in interest rates. It also confirms in particular that the Federal Reserve's second round of bond purchases in 2010 and 2011 did have its intended expansionary effects. Thus, the middle panel of figure 5 shows that while monetary policy contributed to a cumulative decline in output of more than 2 percent from 2008.3 through 2010.4, it has been largely supportive of an accelerating recovery since then.

5. CONCLUSION

Our results call into question the conventional view that the stance of monetary policy can be described with exclusive reference to its effects on interest rates and without consideration of simultaneous movements in the monetary aggregates. Whether by replicating and extending the results of a landmark study or by producing new results from a structural VAR, the message from Divisia monetary aggregates is that money always has had a significant role to play as an intermediate target or indicator variable and that any apparent deterioration in its information content can be traced to the measurement errors inherent in the practice of simple sum aggregation. These results also allow us to see the Federal Reserve's recent policy of "quantitative easing" in a new light: As having its intended stimulative effect by expanding the growth rate of a properly measured value of the money supply, over and above whatever effects it might have had by altering the shape of the yield curve.

Our results also highlight the disconnect between modern New Keynesian models, in which the quantity of money plays no special role once the time path for interest rates is accounted for. In working to bridge this divide, we suspect that researchers will be led to reconsider, as well, the same enduring questions addressed by Bernanke and Blinder (1988) many years ago.

REFERENCES

Anderson, Richard G. and Barry E, Jones. “A Comprehensive Revision of the U.S. Monetary Services (Divisia) Indexes.” Federal Reserve Bank of St. Louis Review 93 (September/October 2011): 325-359.

Barnett, William A. “Economic Monetary Aggregates: An Application of Index Number and Aggregation Theory.” Journal of Econometrics 14 (September 1980): 11-48.

Barnett, William A. Getting It Wrong: How Faulty Monetary Statistics Undermine the Fed, the Financial System, and the Economy. Cambridge: MIT Press, 2012.

Barnett, William A., Jia Liu, Ryan S. Mattson, and Jeff van den Noort. “The New CFS Divisia Monetary Aggregates: Design, Construction, and Data Sources.” Open Economies Review 24 (February 2013): 101-124.

Belongia, Michael T. “Measurement Matters: Recent Results from Monetary Economics Reexamined.” Journal of Political Economy 104 (October 1996): 1065-1083.

Belongia, Michael T. “The Neglected Price Dual of Monetary Quantity Aggregates.” In Michael T. Belongia and Jane M. Binner, Eds. Money, Measurement and Computation. New York: Palgrave Macmillan, 2006.

Belongia, Michael T. and Peter N. Ireland. “The Own-Price of Money and the Channels of Monetary Transmission.” Journal of Money, Credit, and Banking 38 (March 2006): 429-445.

Belongia, Michael T. and Peter N. Ireland. “The Barnett Critique After Three Decades: A New Keynesian Analysis.” Working Paper 17885. Cambridge: National Bureau of Economic Research, March 2012a.

Belongia, Michael T. and Peter N. Ireland. "Quantitative Easing: Interest Rates and Money in the Measurement of Monetary Policy." Working Paper 801. Chestnut Hill: Boston College, Department of Economics, June 2012b.

Bernanke, Ben S. and Alan S. Blinder. "Credit, Money, and Aggregate Demand." American Economic Review 78 (May 1988): 435-439.

Bernanke, Ben S. and Alan S. Blinder. "The Federal Funds Rate and the Channels of Monetary Transmission." American Economic Review 92 (September 1992): 901-921.

Clarida, Richard, Jordi Gali, and Mark Gertler. "The Science of Monetary Policy: A New Keynesian Perspective." Journal of Economic Literature 37 (December 1999): 1661-1707.

Eggertsson, Gauti B. and Michael Woodford. "The Zero Bound on Interest Rates and Optimal Monetary Policy." Brookings Papers on Economic Activity (2003, Issue 1): 139-211.

Friedman, Milton. "Lessons from the 1979-82 Monetary Policy Experiment." American Economic Review 74 (May 1984): 397-400.

Friedman, Milton. "The Fed Hasn't Changed Its Ways." Wall Street Journal (August 20, 1985).

Friedman, Milton and Anna J. Schwartz. A Monetary History of the United States, 1867-1960. Princeton: Princeton University Press, 1963.

Friedman, Benjamin M. and Kenneth N. Kuttner. "Money, Income, Price, and Interest Rates." American Economic Review 82 (June 1992): 472-492.

Hallman, Jeffrey J., Richard D. Porter, and David H. Small. "M2 Per Unit of Potential GNP as an Anchor for the Price Level." Staff Study 157. Washington: Federal Reserve Board, April 1989.

Hallman, Jeffrey J., Richard D. Porter, and David H. Small. "Is the Price Level Tied to the M2 Monetary Aggregate in the Long Run?" American Economic Review 81 (September 1991): 841-858.

Hamilton, James D. Time Series Analysis. Princeton: Princeton University Press, 1994.

Hendrickson, Joshua. "Redundancy or Mismeasurement? A Reappraisal of Money." Manuscript. Detroit: Wayne State University, February 2011.

Hetzel, Robert L. "Monetary Policy in the 2008-2009 Recession." Federal Reserve Bank of Richmond Economic Quarterly 95 (Spring 2009): 201-233.

Ireland, Peter N. "Money's Role in the Monetary Business Cycle." Working Paper 8115. Cambridge: National Bureau of Economic Research, February 2001.

Ireland, Peter N. "A New Keynesian Perspective on the Great Recession." Journal of Money, Credit, and Banking. 43 (February 2011): 31-54.

Ireland, Peter N. "The Macroeconomic Effects of Interest on Reserves." Working Paper 18409. Cambridge: National Bureau of Economic Research, September 2012.

Laidler, David. "Notes on the Microfoundations of Monetary Economics." Economic Journal 107 (July 1997): 1213-1223.

Leeper, Eric M. and Jennifer E. Roush. "Putting 'M' Back in Monetary Policy." Journal of Money, Credit, and Banking 35 (December 2003): 1217-1256.

Leeper, Eric M. and Tao Zha. "Modest Policy Interventions." Journal of Monetary Economics 50 (November 2003): 1673-1700.

McCallum, Bennett T. "Robustness Properties of a Rule for Monetary Policy." Carnegie-Rochester Conference Series on Public Policy 29 (1988): 173-204.

Meltzer, Allan H. "Limits of Short-Run Stabilization Policy." Economic Inquiry 25 (January 1987): 1-14.

Motley, Brian. "Should M2 Be Redefined?" Federal Reserve Bank of San Francisco Economic Review (Winter 1988), pp. 33-51.

Nelson, Edward. "Milton Friedman and U.S. Monetary History: 1961-2006." Federal Reserve Bank of St. Louis Review 89 (May/June 2007): 153-182.

Primiceri, Giorgio E. "Time Varying Structural Vector Autoregressions and Monetary Policy." Review of Economic Studies 72 (July 2005): 821-852.

Sims, C. A. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy." European Economic Review 36 (June 1992): 975-1000.

Sims, Christopher A. and Tao Zha. "Were There Regime Switches in U.S. Monetary Policy?" American Economic Review 96 (March 2006): 54-81.

Tatom, John A. "U.S. Monetary Policy in Disarray." Networks Financial Institute Working Paper 2011-WP-21. Terre Haute: Indiana State University, August 2011.

Taylor, John B. "Estimation and Control of a Macroeconomic Model with Rational Expectations." Econometrica, 47 (September 1979): 1267-1286.

Taylor, John B. "Discretion Versus Policy Rules in Practice." Carnegie-Rochester Conference Series on Public Policy 39 (December 1993): 195-214.

Thoma, Mark A. and Jo Anna Gray. "Financial Market Variables Do Not Predict Real Activity." Economic Inquiry 36 (October 1998): 522-539.

Table 1. Causality Test Results: Sample Period 1967.01 – 1979.09

Forecasted Variable	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.193	**0.024**	**0.034**	0.308	**0.041**	**0.042**
Capacity Utilization	0.186	0.052	**0.013**	0.292	0.124	0.095
Employment	0.493	0.233	0.109	0.619	0.136	0.067
Unemployment Rate	0.152	0.276	0.105	0.215	0.177	0.068
Housing Starts	0.435	**0.020**	**0.030**	0.373	0.063	0.153
Personal Income	**0.000**	**0.017**	**0.044**	**0.000**	**0.003**	**0.003**
Retail Sales	**0.006**	0.133	**0.009**	**0.010**	0.504	0.617
Consumption	0.137	0.486	**0.045**	0.225	0.788	0.871
Durable Goods Orders	**0.045**	**0.017**	**0.008**	**0.046**	**0.032**	**0.019**

Notes: Values are marginal significance levels for the coefficients on the monetary policy variable "X" included in the regression equation (1). Values in bold indicate significance at the 5 percent level.

Table 2. Causality Test Results: Sample Period 1967.01 – 1989.12

Forecasted Variable	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.429	**0.004**	**0.022**	0.180	**0.004**	**0.006**
Capacity Utilization	0.266	**0.030**	**0.014**	0.121	**0.025**	**0.031**
Employment	0.219	**0.002**	**0.001**	0.052	**0.000**	**0.000**
Unemployment Rate	0.108	**0.023**	**0.001**	0.073	0.156	0.070
Housing Starts	0.260	0.089	**0.000**	0.173	**0.019**	**0.028**
Personal Income	0.066	**0.001**	**0.020**	**0.040**	**0.003**	**0.002**
Retail Sales	0.303	**0.000**	**0.000**	0.136	**0.002**	**0.004**
Consumption	0.575	**0.003**	**0.000**	0.664	**0.010**	**0.018**
Durable Goods Orders	0.515	**0.001**	**0.003**	0.306	**0.003**	**0.014**

Notes: See notes to table 1.

Table 3. Causality Test Results: Sample Period 1975.04 – 1989.12

Forecasted Variable	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	**0.043**	0.059	**0.022**	**0.030**	**0.006**	**0.005**
Capacity Utilization	**0.044**	0.141	**0.009**	**0.020**	**0.015**	**0.013**
Employment	**0.019**	**0.018**	**0.004**	**0.014**	**0.003**	**0.002**
Unemployment Rate	**0.044**	**0.010**	**0.001**	**0.029**	**0.030**	**0.035**
Housing Starts	0.767	0.507	**0.002**	0.550	0.198	0.102
Personal Income	0.090	**0.000**	**0.030**	0.074	**0.037**	**0.009**
Retail Sales	0.367	**0.005**	**0.025**	0.146	0.108	**0.039**
Consumption	0.830	0.091	**0.031**	0.747	0.502	0.487
Durable Goods Orders	0.485	0.611	**0.005**	0.444	0.123	0.161

Notes: See notes to table 1.

Table 4. Causality Test Results: Sample Period 1990.01 – 2007.12

Forecasted Variable	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.424	0.690	**0.016**	0.381	0.891	0.943
Capacity Utilization	0.147	0.514	**0.006**	0.294	0.672	0.725
Employment	0.796	0.816	0.736	0.532	0.946	0.892
Unemployment Rate	**0.005**	**0.009**	**0.014**	**0.014**	**0.038**	**0.047**
Housing Starts	0.373	0.677	**0.002**	**0.007**	0.290	0.081
Personal Income	0.778	0.509	0.428	0.676	0.579	0.533
Retail Sales	**0.000**	**0.007**	0.104	**0.000**	**0.003**	**0.001**
Consumption	**0.000**	**0.025**	0.307	**0.000**	**0.021**	**0.002**
Durable Goods Orders	**0.010**	0.094	**0.000**	0.253	0.201	0.226

Notes: See notes to table 1.

Table 5. Causality Test Results: Sample Period 1975.04 – 2007.12

Forecasted Variable	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.129	0.968	**0.005**	**0.004**	0.093	**0.037**
Capacity Utilization	**0.013**	0.371	**0.002**	0.132	0.156	0.213
Employment	0.215	0.744	**0.001**	**0.014**	0.059	**0.030**
Unemployment Rate	0.253	0.174	**0.000**	0.067	0.302	0.180
Housing Starts	0.416	0.221	**0.000**	**0.009**	**0.004**	**0.002**
Personal Income	0.585	0.406	0.178	**0.036**	0.185	0.081
Retail Sales	**0.031**	0.586	**0.046**	**0.002**	0.150	**0.024**
Consumption	0.426	0.669	0.188	0.075	0.328	0.194
Durable Goods Orders	**0.025**	0.398	**0.000**	**0.004**	**0.014**	**0.027**

Notes: See notes to table 1.

Table 6. Causality Test Results: Sample Period 2000.01 – 2013.12

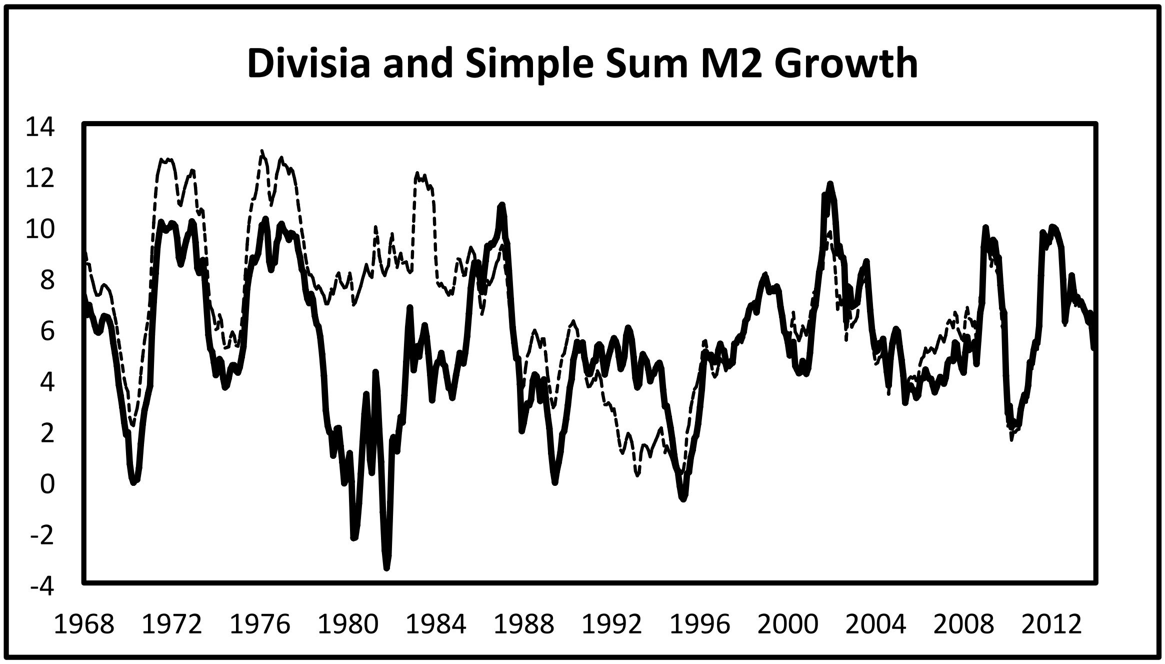
Forecasted Variable	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.334	0.189	0.481	**0.034**	0.142	0.301
Capacity Utilization	0.102	0.191	**0.044**	**0.004**	0.087	0.129
Employment	**0.013**	**0.002**	0.224	**0.010**	**0.000**	**0.008**
Unemployment Rate	**0.003**	**0.008**	0.184	**0.004**	**0.002**	**0.009**
Housing Starts	**0.000**	**0.000**	**0.029**	**0.000**	**0.000**	**0.000**
Personal Income	0.163	0.874	**0.007**	0.152	0.480	0.499
Retail Sales	**0.000**	**0.003**	0.173	**0.000**	**0.001**	**0.000**
Consumption	**0.002**	**0.019**	**0.047**	**0.001**	**0.010**	**0.006**
Durable Goods Orders	0.060	0.080	0.278	**0.014**	**0.034**	0.224

Notes: See notes to table 1.

Table 7. Maximum Likelihood Estimates of Structural Vector Autoregressions

A. Divisia M1		
Recursive	r = 0.20y + 0.39p + 0.06cp m = 0.10y + 0.25p - 0.11r + 0.01cp	L = 3426.22
Taylor Rule with Money	r = -0.02y - 0.23p + 3.54m m - p = 0.38y - 0.83u u = 1.68r + 0.07(m - p)	L = 3424.89
Taylor Rule without Money	r = 0.24y + 0.58p m - p = 0.11y - 0.10u u = 1.38r - 0.07(m - p)	L = 3417.84***
Money-Interest Rate Rule	r = 3.23m m - p = 0.37y - 0.79u u = 1.67r + 0.08(m - p)	L = 3424.86
B. Divisia M2		
Recursive	r = 0.20y + 0.59p + 0.08cp m = 0.13y + 0.28p - 0.19r + 0.01cp	L = 3233.23
Taylor Rule with Money	r = 0.04y + 0.49p + 2.35m m - p = 0.34y - 0.25u u = 4.95r + 1.46(m - p)	L = 3231.90
Taylor Rule without Money	r = 0.25y + 0.86p m - p = 0.17y - 0.07u u = 3.18r + 0.46(m - p)	L = 3226.02***
Money-Interest Rate Rule	r = 3.05m m - p = 0.36y - 0.28u u = 5.10r + 1.33(m - p)	L = 3231.67
C. Divisia MZM		
Recursive	r = 0.22y + 0.58p + 0.07cp m = 0.12y + 0.24p - 0.32r + 0.02cp	L = 3213.39
Taylor Rule with Money	r = 0.17y + 0.75p + 1.81m m - p = 0.39y - 0.30u u = 4.88r + 1.05(m - p)	L = 3212.51
Taylor Rule without Money	r = 0.26y + 0.83p m - p = 0.18y - 0.10u u = 3.51r + 0.45(m - p)	L = 3207.66***
Money-Interest Rate Rule	r = 3.53m m - p = 0.47y - 0.37u u = 5.12r + 0.84(m - p)	L = 3211.95

Notes: Each panel shows the estimates of equations (7) and (8) from the recursive specification or equations (10)-(12) from the non-recursive models, together with the maximized value of the log-likelihood function L. *** denotes that the null hypothesis that money can be excluded from the monetary policy rule is rejected at the 99 percent confidence level. In no case can the null hypothesis that the monetary policy rule includes money and interest rates alone be rejected in favor of the alternative that monetary policy follows the Taylor rule with money.



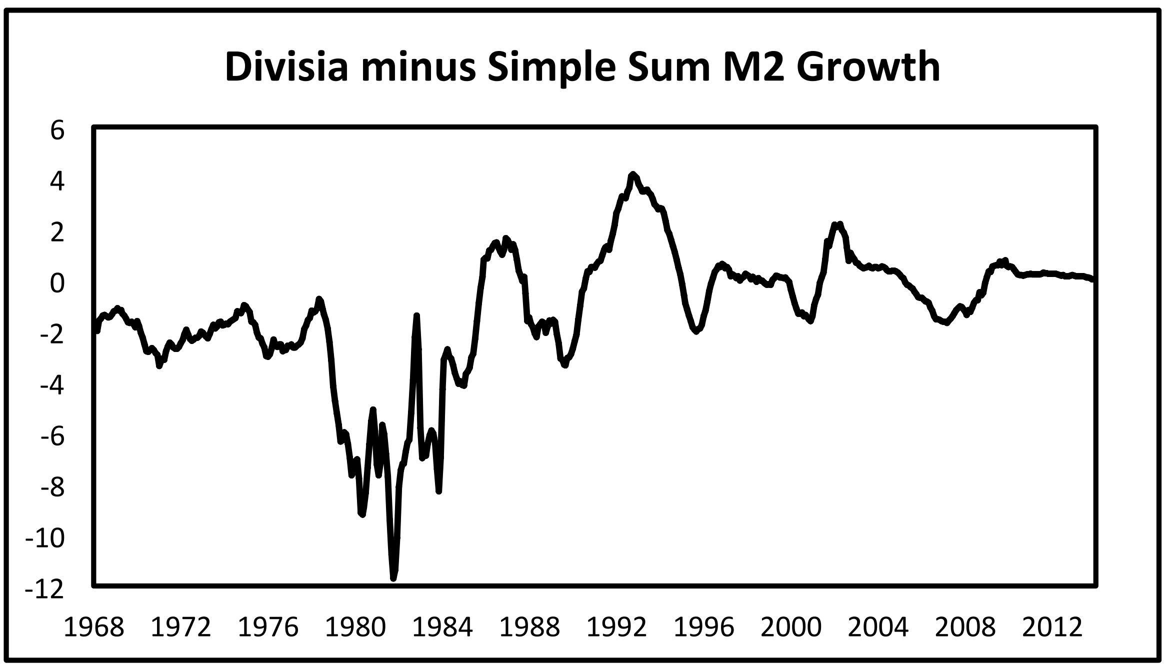


Figure 1. Divisia versus Simple Sum M2 Growth. The top panel shows year-over-year percentage growth rates of the Center for Financial Stability's Divisia M2 aggregate (thick solid line) and the Federal Reserve's official simple sum M2 aggregate (thin dashed line). The bottom panel plots the difference between the two growth rate series.

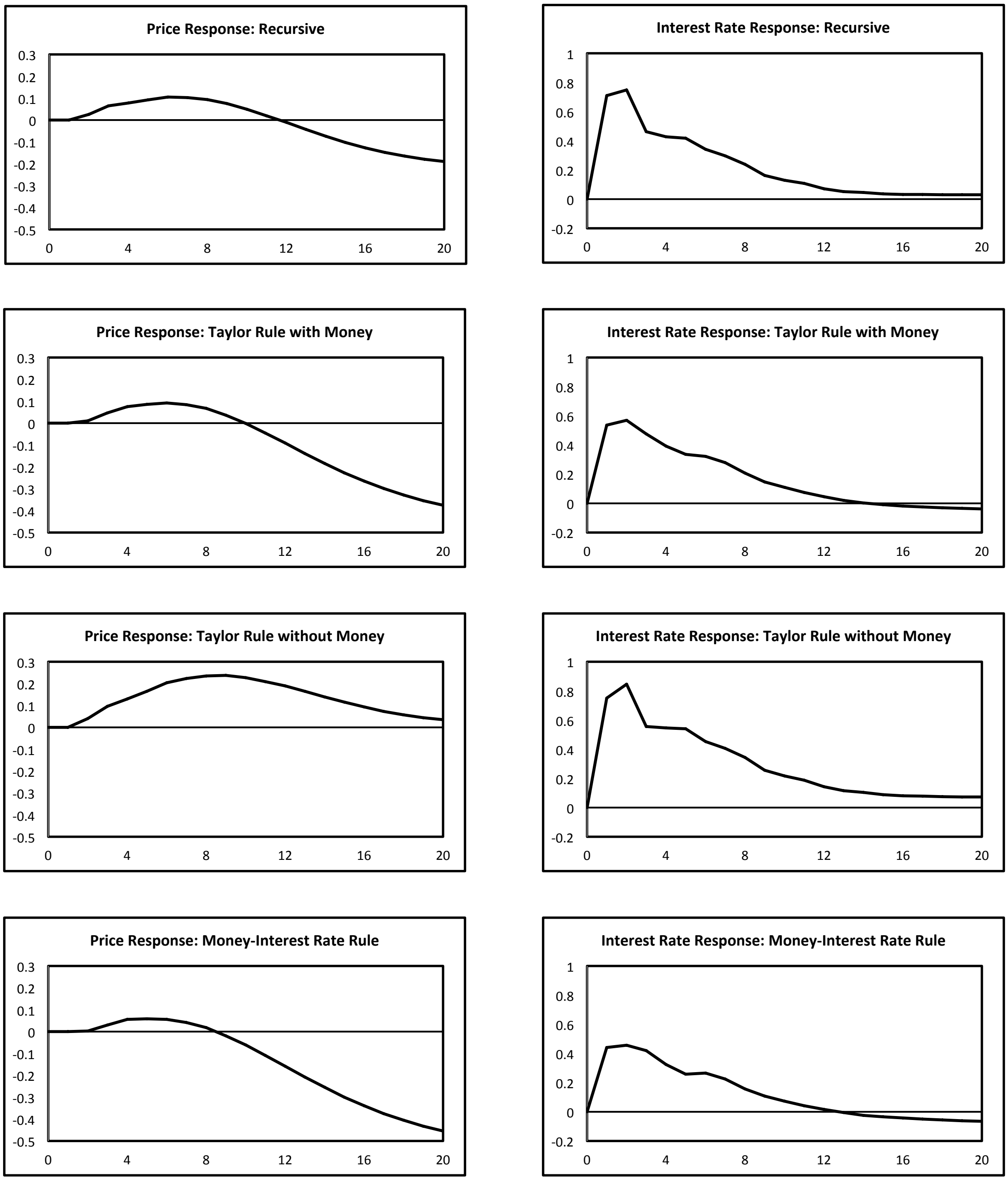


Figure 2. Impulse Responses to Monetary Policy Shocks. Each panel shows the response, in percentage points, of the price level or the interest rate to a one-standard-deviation monetary policy shock, derived under one of the four identification schemes described in the text. In each case, money is measured by the CFS's Divisia MZM monetary aggregate.

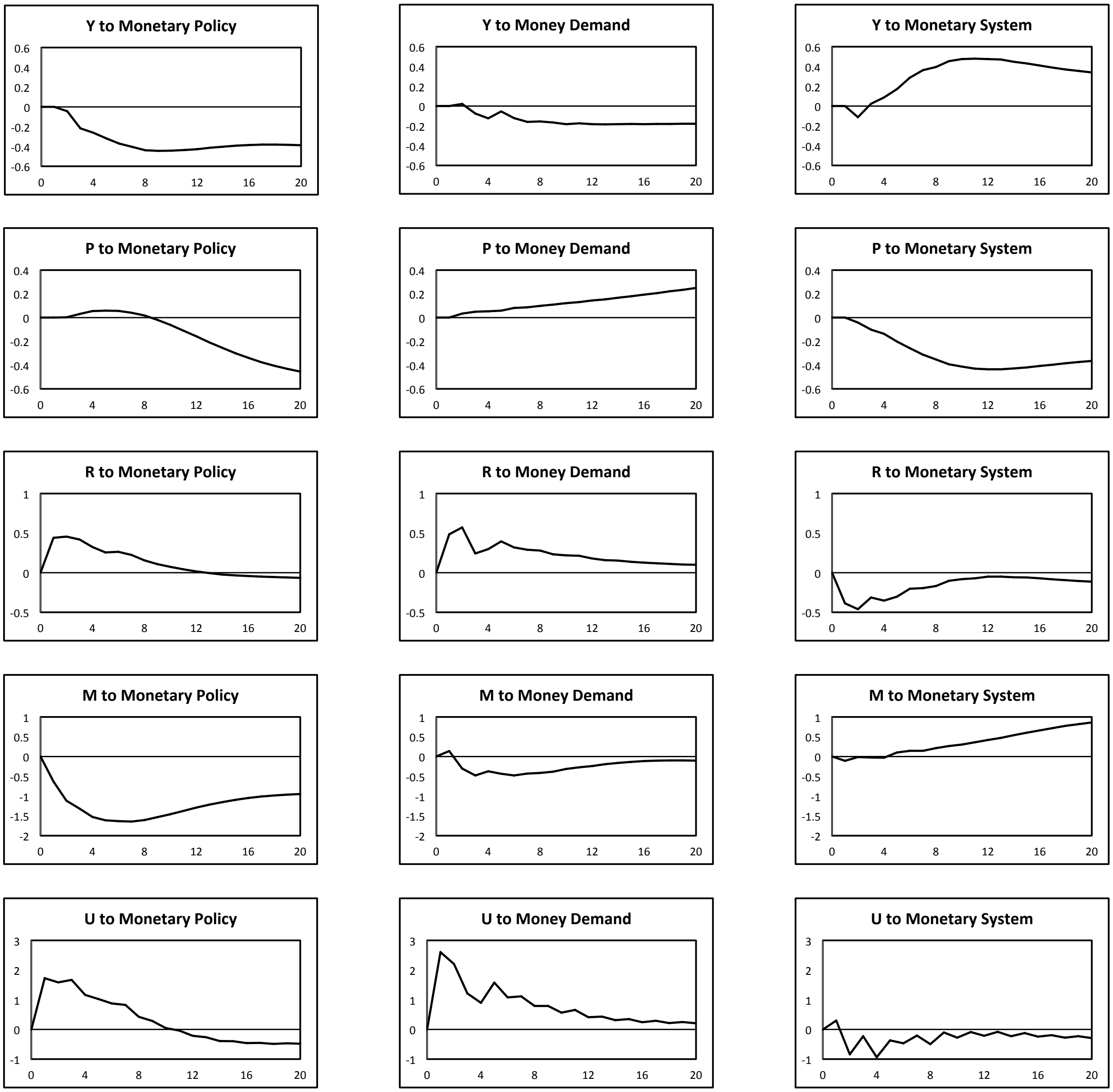


Figure 3. Impulse Responses. Each panel shows the response, in percentage points, of the indicated variable to the indicated one-standard-deviation shock, as implied by the structural VAR with the money-interest rate rule. Money is measured by the CFS's Divisia MZM monetary aggregate.

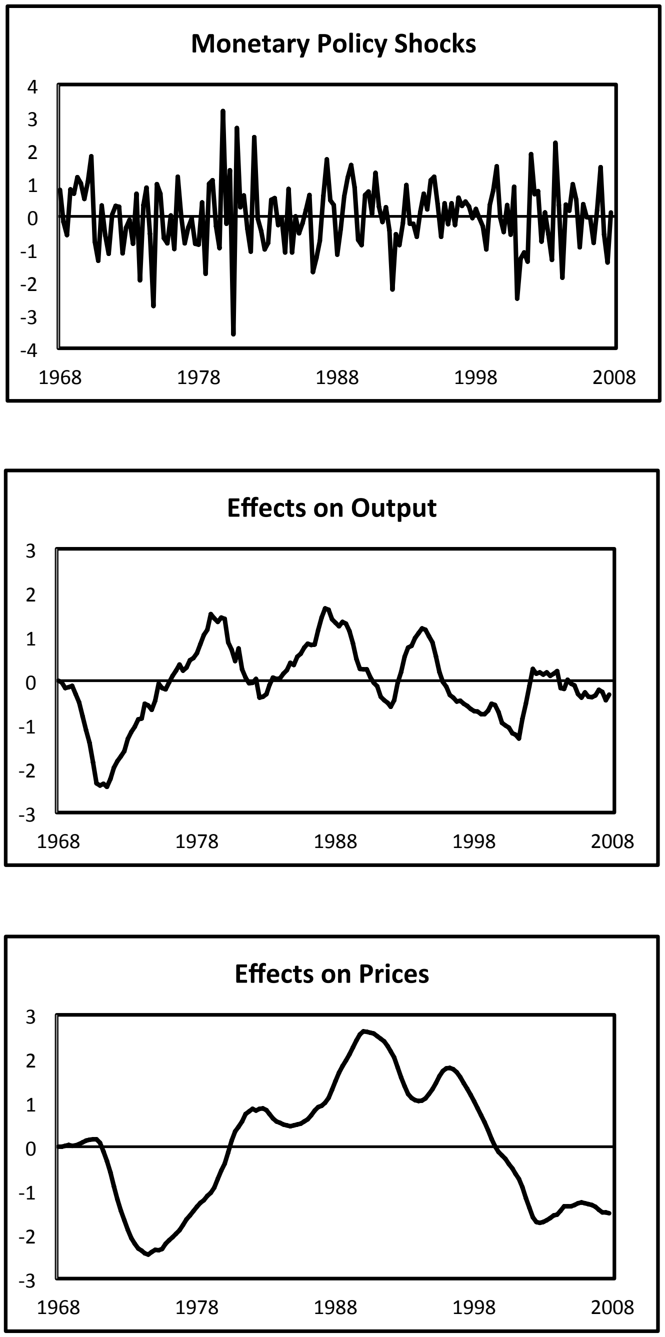


Figure 4. Monetary Policy Shocks and Their Effects. The top panel plots the serially uncorrelated monetary policy shock from structural VAR with the money-interest rate rule, estimated with data from 1967.1 through 2007.4. Money is measured by the CFS's Divisia MZM monetary aggregate. The bottom two panels plot the cumulative effects of these shocks on output and prices, as percentage-point differences between the actual value of each variable at each date minus the value that, according to the estimated VAR, would have obtained in the absence of monetary policy shocks over the entire sample.

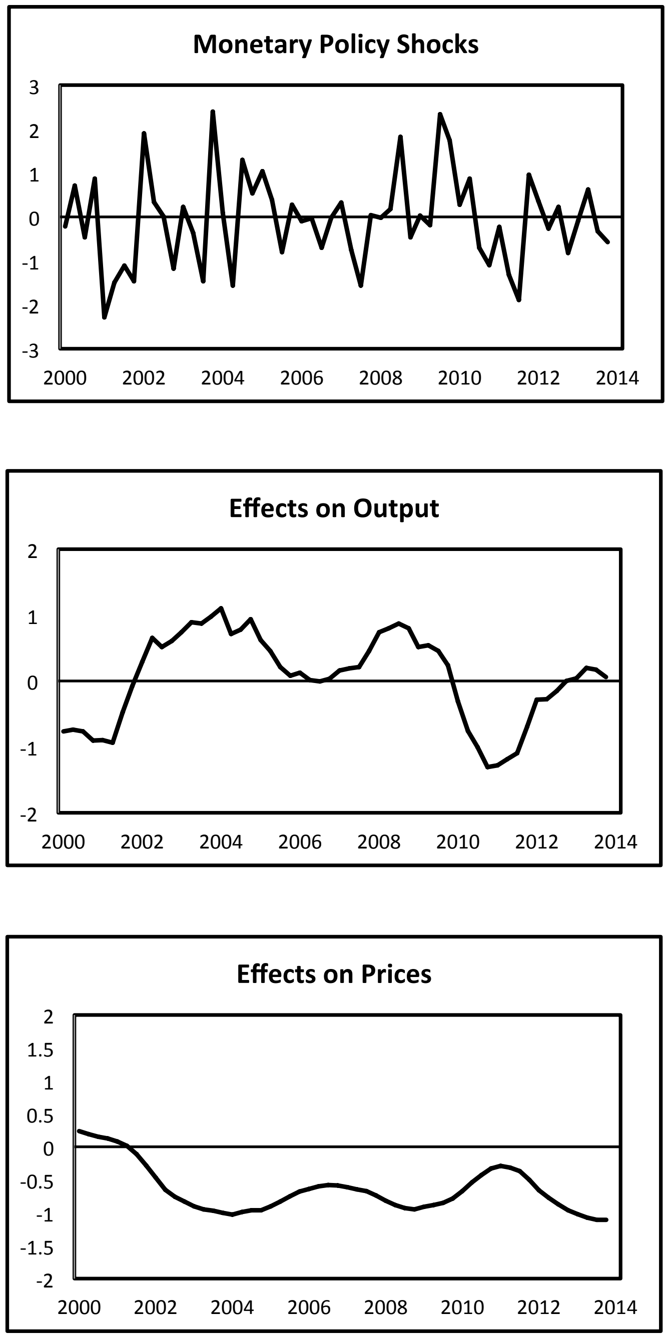
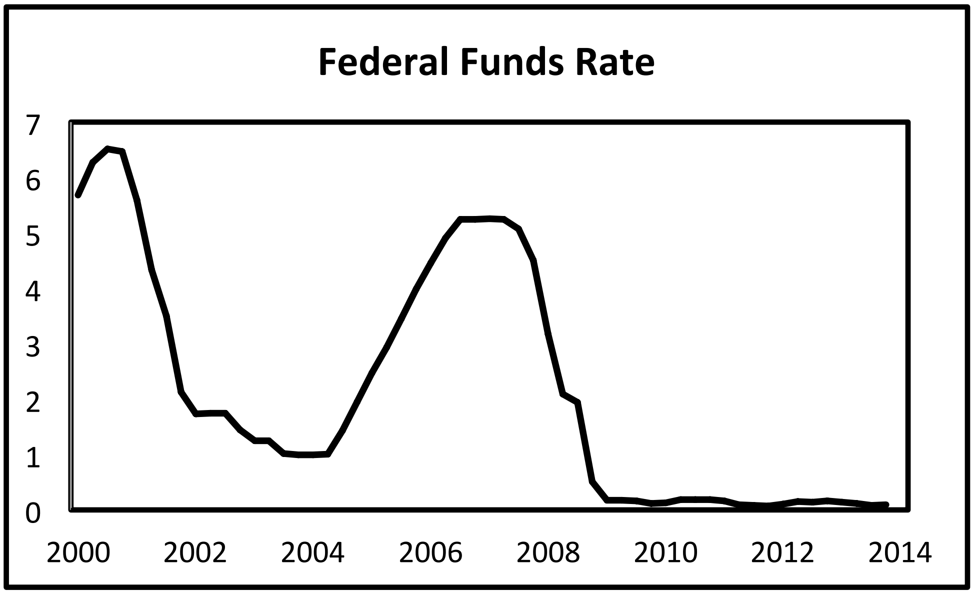


Figure 5. Monetary Policy Shocks and Their Effects. The top panel plots the serially uncorrelated monetary policy shock from structural VAR with the money-interest rate rule, estimated with data from 1967.1 through 2013.4. Money is measured by the CFS's Divisia MZM monetary aggregate. The bottom two panels plot the cumulative effects of these shocks on output and prices, as percentage-point differences between the actual value of each variable at each date minus the value that, according to the estimated VAR, would have obtained in the absence of monetary policy shocks over the entire sample.



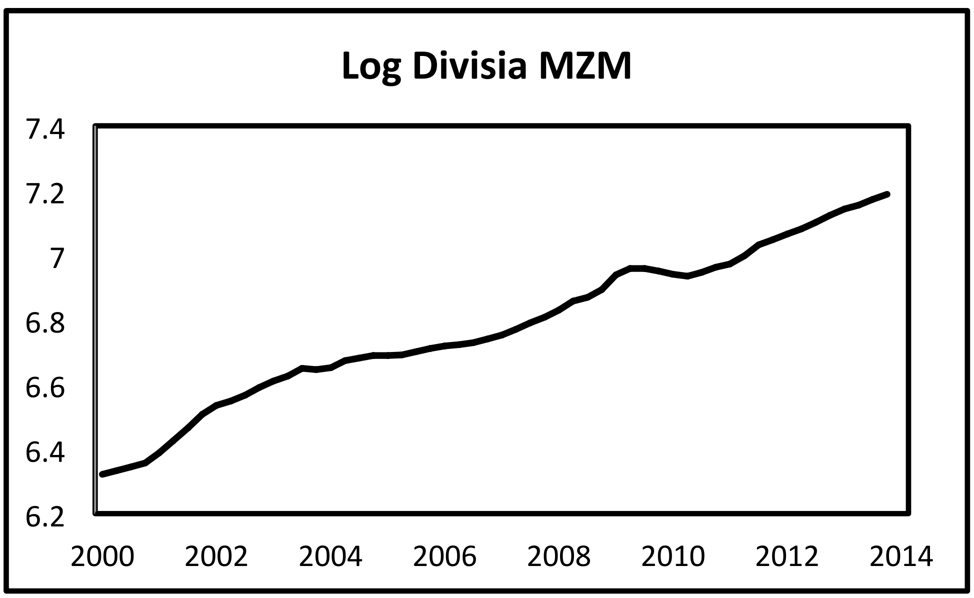


Figure 6. Interest Rates and the Money Stock. The top panel shows the effective federal funds rate and the second panel shows the log of the CFS's Divisia MZM monetary aggregate; both series are quarterly and run from 2000.1 through 2013.4.