Quantitative Easing: Interest Rates and Money in the Measurement of Monetary Policy[*]

Michael T. Belongia
Otho Smith Professor of Economics
University of Mississippi
Box 1848
University, MS 38677
mvpt@earthlink.net

Peter N. Ireland
Department of Economics
Boston College
140 Commonwealth Avenue
Chestnut Hill, MA 02467
peter.ireland@bc.edu

September 2012

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 as a radical break from standard practice. Alternatively, one could take the view that the monetary aggregates might not have disappeared from standard models and policy discussions if they had been measured properly and interpret the new policy initiatives simply as conventional attempts to increase money growth. Indeed, superlative (Divisia) measures of money often help in forecasting movements in key macroeconomic variables, and 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.

JEL Codes: E51, E52, E58.

---

[*] We would like to thank Josh Hendrickson, David Laidler, and Ed Nelson for extremely helpful comments on previous drafts and Richard Anderson, William Barnett, and Barry Jones for useful conversations and for their patience in answering questions about the construction of their series for the Divisia monetary aggregates. Dekuwmini Mornah provided able research assistance. Neither author received external support for, or has any financial interest that relates to, the research described in this paper.

Quantitative Easing: Interest Rates and Money in the Measurement of Monetary Policy

Nearly twenty-five years ago, Bernanke and Blinder (1988) compactly summarized the choice facing a central bank. After modifying a standard, Keynesian IS curve so that it could absorb 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.

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 had abandoned its practice of monetary targeting in October 1982 and, since that time, had implemented monetary policy with a variety of approaches to targeting the federal funds rate.[1] 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.[2]

These cracks grew larger, and the brief flirtations with nominal GDP targeting grounded in Quantity Theory foundations were abandoned, when several key papers were published in the early 1990s. First, in June 1992, Friedman and Kuttner 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, however, 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 presenting their own results, this time focused on the role of the federal funds rate in the monetary transmission mechanism. Like

---

[1] See Gilbert (1994) for a discussion of whether the Federal Reserve ever targeted a path for money growth between October 1979 and October 1982. Gilbert (1985) offers background on the various approaches to the implementation of monetary policy that were taken between 1970 and 1985.

[2] For details on the role that money supply measurement played in this episode, see the discussion and analysis in Nelson (2007, pp.162-168) and Barnett (2012, pp.107-111).

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 basic idea 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 previous 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 examined whether money still could be related to movements in aggregate economic activity and 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 article, which showed how the simple and now-famous rule that bears his name appears to track quite well how the Federal Reserve adjusted its federal funds rate target in response to movements in output and inflation during the late 1980s and early 1990s, strongly reinforced this shift in emphasis, so that by the end of the 1990s the mainstream macro model outlined by Clarida, Gali, and Gertler (1999) included an equation for the federal funds rate but did not include 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 the current and expected future path of the short-term nominal interest rate.

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 it is known that simple sum indexes cannot internalize pure substitution effects, the Federal Reserve's official money supply data incorporate measurement error of unknown magnitude in their construction that will influence economic inference.[3] Our results add to and complement most directly those of Belongia (1996) and Hendrickson (2011): They show that when Divisia measures of money are included in the place of their simple sum counterparts in the predictive regressions for the range of variables considered by Bernanke and Blinder (1992), these quantity measures contain information and possess significant explanatory power comparable to that found in interest rates and interest rate spreads.

Encouraged by these preliminary results, we go on to derive a second set by incorporating Divisia measures of money into a structural vector autoregression similar to that developed by Leeper and Roush (2003). In setting up this econometric framework, we show how the use of Divisia monetary aggregates allows not only for better measurement of the key

---

[3] Barnett (1980) is the classic reference on this topic; see Barnett (2012) and Belongia and Ireland (2012) for more recent discussions.

variables, but also for a more theoretically appealing depiction of the demand for monetary services, to 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 linking interest rates to output and prices alone 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. Making use of valuable new data on the Divisia aggregates provided by the Federal Reserve Bank of St. Louis and the Center for Financial Stability described by Anderson and Jones (2011) and Barnett, Liu, Mattson, and van den Noort (2012), we find that our results are robust to the level of monetary aggregation: The choice between M1, M2, M3, and so on seems unimportant, once one uses the Divisia aggregation method in place of the simple sum. 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 2008; strikingly, these results corroborate Barnett's (2012) arguments that monetary instability looms as an important factor in recent US monetary history, while also providing 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 is certainly not that interest rates play no role in the process through which monetary policy actions are transmitted to output, prices, and other macroeconomic variables. 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 Berkanke and Blinder's (1988) work appeared.

The Information Content of Interest Rates and Money

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

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

where Y_t is one of several measures of real activity to be explained, X_t is a measure of the monetary transmission mechanism, 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,…,6, are regression coefficients, and six lags of each monthly variable appear on the right-hand side. Although the tables list each measure of real activity used in the analysis, these 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, on the one hand, to the effects of measurement on inferences about money's effect on economic activity and, on the other, to the relative influences of monetary aggregates and the funds rate on real activity, we report in what follows 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 Anderson and Jones' (2011) Divisia measures of M1, M2 and MZM (M2, less small time deposits, plus Institution-only Money Market Mutual Funds).[4] The latter measure 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 simple sum and Divisia measures of M2 that we use throughout. 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 the growth rates of these Divisia and sum measures of M2. Important differences appear across the two series, particularly during the Volcker disinflation, where the Divisia measure provides a much stronger signal of monetary tightening. Smaller, but still quite noticeable, differences also arise before, during, and after the most recent recessions of 1990-91, 2001, and 2007-2009; again, in each case, the Divisia aggregate suggests a sharper tightening of monetary policy. Moreover, a standard Augmented Dickey-Fuller test on the difference variable, shown in the bottom panel of figure 1, indicates that this series is not stationary.[5] 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

---

[4] Motley (1988), who originally discussed the logic of this grouping and investigated its empirical properties relative to the traditional aggregates, had called it "non-term M3." It later became known as MZM: money-zero maturity.

[5] The ADF statistic is -2.27 against a 0.05 critical value of -2.88.

monitoring sum M2 rather than its Divisia counterpart. Thus, both this visual comparison and basic statistical result confirm Barnett's (1980) message that the distinction between simple sum and Divisia monetary aggregation matters and suggest, more specifically, that the Divisia aggregates will likely perform better than their simple sum counterparts in capturing the true stance of monetary policy and forecasting the trajectory of the economy.

With six measures of how monetary policy might influence alternative indicators of real activity, we were left with choices about sample periods for the estimation period. In a perfect world, we would have been able to replicate all of the samples in the original Bernanke and Blinder work but this was not possible because the Divisia data originate in January 1967 and the first sample for the original study began in 1959. We terminated 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 estimated the same relationships on data drawn completely beyond the terminal date of the original study. In all, the basic causality framework suggested by Bernanke and Blinder was repeated across five samples and these results are reported in tables 1 through 5. In each case, we were 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 would show no effect on economic activity, yet be linked to economic activity by a Divisia measure? Second, would Divisia measures of money and the funds rate be 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 1967.07, 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. 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 have effects on multiple measures of economic activity. 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 mentioned in Thoma and Gray (see their footnote 2) is unknown.

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: Although both have significant effects on personal income, sum M1 also has a significant effect on employment and both have marginal significance values of 0.06 in predicting durable goods orders. In the case of M2, both sum and Divisia measures are significantly associated with three measures of real activity. 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 six of the nine measures. And, while the funds rate still is related to eight of the nine measures, these results hardly can be interpreted as evidence that money lost its ability to explain aggregate fluctuations after the 1970s. To the extent this case can be made, it lies in the table's first two columns where the Federal Reserve's simple sum measures of M1 and M2 are significant in three and four of the nine cases, respectively.

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 1975.10 – 1989.12. Although this sample still includes an ample number of observations, the funds rate loses its significance for two variables (employment and retail sales). Still, the funds rate, which had been associated with eight of the nine measures of real activity, remains associated with seven of the measures over this sample. By comparison, the influence of the monetary aggregates is largely unaffected; Divisia M2 is related significantly to five of the measures and has a sixth marginal significance level that is barely above the five percent level. Divisia MZM exhibits a statistically significant effect on seven of the nine measures of economic activity. As a general impression, the results in Table 3 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 exhibit significant associations with a majority of the indicators of business cycle activity.

Table 4 reports results for a sample drawn from data completely beyond the publication of the original study, 1990.07 – 2007.12. Several things are interesting here. First, if one were looking for evidence that measurement is an issue for monetary aggregation, the results in this table (as well as the next) offer it. In this case, simple sum M1 and M2 now are related only to retail sales and consumption whereas Divisia M1 is related to those variables as well as the unemployment rate and housing starts (with a marginal significance level of seven percent for employment). Divisia MZM is related significantly to three measures of activity. Conversely, the funds rate is related to five of the nine measures of economic activity and, with the exception of housing starts and the unemployment rate, to different measures of activity than those that are 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 how the metric by which economic activity is measured as well.

Finally, table 5 reports from estimations across the 1975.10 – 2007.12 period, which abstracts from the interest rate outlier issue and ends prior to the beginning of the most recent economic downturn. In this case, the funds rate is related to five measures of economic activity, Divisia M1 is linked to four, Divisia MZM to three and Divisia M2 to one (with three marginal significance levels below 0.07). In contrast, each simple sum contributes significantly to the explanation of movements of only one variable.

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 or the tables that precede it. But, as in the case of Belongia (1996) and Hendrickson (2011), these results do present another case 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.

Measuring Monetary Policy

To dig deeper into the sources of the links between money, interest rates, output, and prices reflected in the causality test results just described, we next follow Leeper and Roush (2003), by building 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 Federal Reserve Bank of St. Louis' Divisia monetary aggregates described by Anderson and Jones (2011) 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 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), of including a measure of commodity prices PC_t – the CRB/BLS spot index now compiled by the Commodity Research Bureau – in the VAR as well. 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 complications associated with the zero lower bound on the federal funds rate, although we also consider results that follow when the sample is extended through 2011.4. 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

$$X_t = [P_t \quad Y_t \quad CP_t \quad R_t \quad M_t \quad U_t]', \tag{2}$$

the structural model takes the form

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

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 mean-zero, serially uncorrelated structural disturbances, normally distributed with

$$E\varepsilon_t\varepsilon_t' = I. \tag{4}$$

The reduced form associated with (3) is

$$X_t = \mu + \sum_{j=1}^{q} \Phi_j X_{t-j} + x_t, \tag{5}$$

where the 6x1 vector of zero-mean disturbances

$$x_t = [p_t \quad y_t \quad cp_t \quad r_t \quad m_t \quad u_t]' \tag{6}$$

is such that

$$Ex_t x_t' = \Sigma. \tag{7}$$

Comparing (3) and (4) to (5) and (7) reveals that the structural and reduced-form disturbances are linked via

$$Ax_t = \varepsilon_t \tag{8}$$

where

$$A = B^{-1}. \tag{9}$$

The same comparison implies that

$$BB' = \Sigma . \tag{10}$$

Since the covariance matrix Σ for the reduced-form innovations contains only 21 distinct elements, however, 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 diagonal. 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, ignoring 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 the others, in this case one might also interpret the fourth line in the vector of equations from (8),

$$a_{41}p_t + a_{42}y_t + a_{43}cp_t + a_{44}r_t = \varepsilon_t^{mp} , \tag{11}$$

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.[6] Likewise, the fifth line in (8),

$$a_{51}p_t + a_{52}y_t + a_{53}cp_t + a_{54}r_t + a_{55}m_t = \varepsilon_t^{md} \tag{12}$$

---

[6] Note, however, that this Taylor rule serves only to capture the contemporaneous co-movement between the variables in (11); interest rate smoothing, and any other systematic responses of Federal Reserve policy to lagged data, will be reflected in the autoregressive coefficients in (3) and (5).

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 (8) 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.[7] Our benchmark non-recursive model parameterizes the matrix A as

$$A = \begin{pmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & 0 & a_{44} & a_{45} & 0 \\ -a_{55} & a_{52} & 0 & 0 & a_{55} & a_{56} \\ -a_{65} & 0 & 0 & a_{64} & a_{65} & a_{66} \end{pmatrix}. \tag{13}$$

Only 19 free parameters enter into (13), implying that the model satisfies the necessary conditions for recovering the structural disturbances in ε_t from the reduced-form innovations x_t via (8). The first two rows in (13) 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,

---

[7] El-Shagri, Giesen, and Kelly (2012) take yet another approach to identifying monetary policy shocks in a VAR that includes a Divisia monetary aggregate, imposing sign restrictions as suggested by Faust (1998) and Canova and De Nicolo (2002), but do not test their preferred representation of monetary policy against others that exclude money as we do here.

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 (13) 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:

$$a_{41}p_t + a_{42}y_t + a_{44}r_t + a_{45}m_t = \varepsilon_t^{mp}, \tag{14}$$

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 (14) 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. 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:

$$a_{52}y_t + a_{55}(m_t - p_t) + a_{56}u_t = \varepsilon_t^{md} \tag{15}$$

Belongia (2006) advocates forcefully money demand relationships of this form over more commonly-used specifications, like (12), 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 (13),

$$a_{64}r_t + a_{65}(m_t - p_t) + a_{66}u_t = \varepsilon_t^{ms} \tag{16}$$

summarizes the behavior of the private financial institutions that, together with the Federal Reserve, create liquid assets that provide US households and firms with monetary services. Belongia and Ireland (2012) 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; equation (15) 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 (15), ε_t^{ms} can be interpreted as a shock to the monetary system that makes it more difficult and expensive to create monetary assets.

Compared to the recursive identification scheme described initially, therefore, the non-recursive specification in (13) 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, (13) 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, (13) 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 (13), (14) 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 (14) 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.[8]

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 (5). For the recursive identification scheme in which the matrix A is simply required to be lower-diagonal, the usual approach is followed, in which the matrix B in (10) is found through the Cholesky factorization of the covariance matrix Σ of the reduced-form innovations. For the non-recursive system (13) 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 6 summarizes the results from estimating the vector autoregression under each of the four identification schemes: the recursive model, the structural model (13), and the two more highly constrained versions of (13) just described. As noted above, the quarterly sample period in each case begins in 1967.1 and runs through 2007.4. And while table 6 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 in the appendix report the full range of results derived with all of the other Divisia quantity and user-cost series provided by Anderson and Jones (2011) at the St. Louis Federal Reserve Bank and by Barnett, Liu, Mattson, and van den Noort (2012) at the Center for Financial Stability.

---

[8] Leeper and Zha (2003) and Sims and Zha (2006) also incorporate money-interest rate rules of this simple form into structural vector autoregressive models.

To help prevent readers from getting lost in a forest of numbers, table 6 displays estimates of the monetary policy and money demand equations (11) and (12) for the recursive model and the money policy, money demand, and monetary system equations (14)-(16) 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 very few exceptions, the "correct" signs.[9] 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 federal 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 equation (16) 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

---

[9] In fact, a closer look at table 6 reveals that estimated coefficients with the "wrong" signs appear only in cases where Divisia M1 or M2 is included together with GDP and the GDP deflator in the expanded Taylor rule (14). Moreover, in those cases, it is the coefficients on output and prices that are incorrectly signed, foreshadowing the additional results described below, which suggest that monetary policy is modeled more parsimoniously and accurately in this framework by a relationship between the interest rate and the money stock alone.

the user costs, consistent with an 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 (14), 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 (14) 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 95 or 99 percent confidence levels while, in the meantime, the constraints excluding prices and output from the policy rule can be imposed without any significant deterioration in the model’s statistical fit.

This first set of results reinforces those presented by Leeper and Roush (2003), casting 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) 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 M4 in drawing the main message from table 6, together with the additional tables in the appendix: that money does seem to matter, importantly, in describing the effects of Federal Reserve policy.

To be fair, we acknowledge next that table 6 also reveals that even the most flexible non-recursive model we estimate yields a lower value for the maximized log-likelihood function than the recursive model, implying that the null hypothesis that the two overidentifying restrictions incorporated into (13) hold can also be rejected at the 95 or 99 confidence levels.[10] Figure 2, however, 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 Anderson and Jones' (2011) Divisia MZM index of monetary services, but once again similar findings emerge when any of the other Divisia aggregates – narrower or broader – 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 (11), 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 follow a contractionary policy shock. And strikingly, here, the price puzzle vanishes almost entirely in the last row of figure 2, where the simplest

---

[10] Note, however, that the alternative against which this null hypothesis is being tested is embodied not by the particular recursive model we choose here, but the entire class of just-identified models, including each of the other recursive models obtained by reordering the variables in the vectors (2) and (6), all of which yield the same value of the maximized log-likelihood function.

money-interest rate rule replaces the Taylor-type rules; in this 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 it also produces a series of identified monetary policy shocks that most reliably associate monetary contractions 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 (14)-(16) – 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, more narrow or broad. The first column of figure 3 shows that the fall in prices and rise in the interest rate shown in figure 2 to 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, 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, in which aggregate prices rise following a positive shock to money demand. 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 (16) describing the behavior of the private financial sector generates a small but still noticeable decline in output and a larger 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, mitigating but not completely eliminating the decrease in 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) and (4) normalize 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.[11] 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 2004.2 and continuing through the end of the sample in 2007.4. 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 vector autoregression, 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 have hit the economy.

---

[11] 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.

As noted above, the binding constraint on the federal funds rate at zero makes us hesitate to use a linear model like ours to interpret data during and since the financial crisis of 2008 and the severe recession that followed. And indeed, adding the last four years of data to extend the sample period through 2011.4 turns out to have large effects not just on the coefficients that enter into the matrix A governing the mapping (8) from reduced-form innovations to structural disturbances but also on the autoregressive parameters contained in the matrices Φ_j, j=1,2,…,q, governing the model's dynamics. These effects can be seen, for example, in figure 5, which replicates the historical analysis from figure 4 after the model is re-estimated with data from 1967.1 through 2011.4, still using the St. Louis Fed's Divisia MZM aggregate and our preferred money-interest rate policy rule.

Despite our reservations about this last step in the exercise, it is impossible to resist looking at what, in the top panel of figure 5, the model has to say about the most recent episodes in US monetary history. The monetary policy shocks 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 unfortunately to its length and severity. On the other hand, the shocks become expansionary from 2010.3 through 2011.3. Our model, which assigns a key role to money in the policy rule, interprets every episode of monetary easing as "quantitative easing," but confirms in particular that the Federal Reserve's second round of bond purchases in 2010 and 2011 did have its intended expansionary effects.

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.” Manuscript. New York: Center for Financial Stability, 2012.

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 2012.

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.

Canova, Fabio and Gianni De Nicolo. "Monetary Disturbances Matter for Business Fluctuations in the G-7." Journal of Monetary Economics 49 (September 2002): 1131-1159.

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.

El-Shagi, Makram, Sebastian Giesen, and Logan Kelly. "Monetary Policy in a World Where Money (Also) Matters." Discussion Paper 6. Halle: Halle Institute for Economic Research, July 2012.

Faust, Jon. "The Robustness of Identified VAR Conclusions About Money." Carnegie-Rochester Conference Series on Public Policy 49 (December 1998): 207-244.

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

Gilbert, R. Alton. "Operating Procedures for Conducting Monetary Policy." Federal Reserve Bank of St. Louis Review (February 1985): 12-21.

Gilbert, R. Alton. "A Case Study in Monetary Control: 1980-82." Federal Reserve Bank of St. Louis Review 76 (September/October 1994): 35-58.

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.” Manuscript. Chestnut Hill: Boston College, May 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, 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. “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. Replications and Extensions of the Causality Tests Reported by Bernanke and Blinder (1992)

Sample Period: 1967.07 – 1979.09

	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.388	0.369	**0.035**	0.434	0.579	0.446
Capacity Utilization	0.441	0.229	**0.023**	0.484	0.447	0.639
Employment	**0.041**	**0.002**	**0.001**	0.066	**0.004**	**0.006**
Unemployment Rate	0.333	0.101	**0.007**	0.358	0.240	0.479
Housing Starts	0.392	**0.004**	**0.010**	0.376	**0.005**	**0.046**
Personal Income	**0.026**	0.091	**0.006**	**0.024**	**0.047**	**0.010**
Retail Sales	0.087	**0.010**	**0.034**	0.116	0.086	0.164
Consumption	0.570	0.705	0.165	0.656	0.894	0.903
Durable Goods Orders	0.057	0.070	0.107	0.062	0.084	0.097

Note: Values in the table 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. Replications and Extensions of the Causality Tests Reported by Bernanke and Blinder (1992)

Sample Period: 1967.07 – 1989.12

	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.088	0.054	**0.000**	0.054	**0.030**	**0.004**
Capacity Utilization	0.389	0.334	**0.000**	0.516	0.284	0.151
Employment	**0.039**	**0.000**	0.204	**0.000**	**0.000**	**0.000**
Unemployment Rate	0.347	0.056	**0.000**	0.382	0.419	0.308
Housing Starts	0.141	**0.007**	**0.000**	0.066	**0.000**	**0.002**
Personal Income	**0.041**	**0.003**	**0.002**	**0.020**	**0.010**	**0.004**
Retail Sales	0.578	0.074	**0.013**	0.467	0.207	0.475
Consumption	**0.040**	**0.004**	**0.001**	**0.004**	**0.001**	**0.001**
Durable Goods Orders	0.074	0.080	**0.000**	0.070	**0.024**	**0.006**

Note: Values in the table 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 3. Replications and Extensions of the Causality Tests Reported by Bernanke and Blinder (1992)

Sample Period: 1975.10 – 1989.12

	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	**0.020**	**0.041**	**0.000**	**0.026**	**0.002**	**0.001**
Capacity Utilization	**0.018**	0.130	**0.000**	**0.029**	**0.005**	**0.001**
Employment	0.068	**0.004**	0.411	**0.016**	**0.000**	**0.001**
Unemployment Rate	**0.048**	0.087	**0.050**	0.064	0.127	**0.016**
Housing Starts	0.188	**0.038**	**0.018**	0.156	**0.019**	**0.003**
Personal Income	0.266	**0.034**	**0.044**	0.318	0.189	**0.025**
Retail Sales	0.153	0.131	0.287	0.125	0.202	0.314
Consumption	0.153	0.260	**0.026**	0.070	0.057	0.113
Durable Goods Orders	**0.025**	0.731	**0.002**	**0.039**	**0.032**	**0.003**

Note: Values in the table 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 4. Replications and Extensions of the Causality Tests Reported by Bernanke and Blinder (1992)

Sample Period: 1990.07 – 2007.12

	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.424	0.846	**0.002**	0.333	0.925	0.857
Capacity Utilization	0.370	0.651	**0.001**	0.625	0.715	0.686
Employment	0.230	0.055	**0.028**	0.070	0.103	0.118
Unemployment Rate	0.082	0.493	**0.000**	**0.033**	0.631	0.144
Housing Starts	0.401	0.672	**0.003**	**0.023**	0.340	**0.045**
Personal Income	0.493	0.870	0.383	0.548	0.791	0.586
Retail Sales	**0.000**	**0.002**	0.644	**0.000**	**0.000**	**0.000**
Consumption	**0.000**	**0.005**	0.209	**0.000**	**0.001**	**0.000**
Durable Goods Orders	0.978	0.964	0.565	0.368	0.973	0.694

Note: Values in the table 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 5. Replications and Extensions of the Causality Tests Reported by Bernanke and Blinder (1992)

Sample Period: 1975.10 – 2007.12

	Simple Sum M1	Simple Sum M2	Federal Funds	Divisia M1	Divisia M2	Divisia MZM
Industrial Production	0.507	0.852	**0.000**	**0.010**	0.120	**0.026**
Capacity Utilization	0.408	0.868	**0.000**	0.069	0.068	**0.035**
Employment	0.313	0.137	0.551	**0.040**	0.068	0.158
Unemployment Rate	0.978	0.916	**0.000**	**0.024**	0.682	0.416
Housing Starts	0.128	**0.043**	**0.000**	**0.007**	**0.000**	**0.000**
Personal Income	0.460	0.857	0.394	0.297	0.578	0.329
Retail Sales	0.288	0.649	**0.017**	0.841	0.242	0.122
Consumption	**0.002**	0.411	0.302	0.189	0.212	0.076
Durable Goods Orders	0.976	0.690	0.082	0.321	0.667	0.260

Note: Values in the table 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 6. Maximum Likelihood Estimates of Structural VARs

A. Divisia M1

Recursive	$r = 0.20y + 0.41p + 0.06cp$ $m = 0.15y + 0.21p - 0.12r + 0.01cp$	L = 3467.07
Taylor Rule with Money	$r = -0.23y - 0.02p + 3.65m$ $m - p = 0.61y - 1.66u$ $u = 1.13r + 0.20(m - p)$	L = 3463.70
Taylor Rule without Money	$r = 0.25y + 0.59p$ $m - p = 0.19y - 0.18u$ $u = 0.87r + 0.10(m - p)$	L = 3454.82***
Money-Interest Rate Rule	$r = 2.88m$ $m - p = 0.54y - 1.44u$ $u = 1.11r + 0.22(m - p)$	L = 3463.46

B. Divisia M2

Recursive	$r = 0.19y + 0.64p + 0.07cp$ $m = 0.13y + 0.32p - 0.20r - 0.00cp$	L = 3474.13
Taylor Rule with Money	$r = -0.25y - 0.07p + 6.27m$ $m - p = 0.31y - 1.23u$ $u = 1.36r + 0.46(m - p)$	L = 3467.48
Taylor Rule without Money	$r = 0.25y + 0.85p$ $m - p = 0.16y - 0.30u$ $u = 0.91r + 0.33(m - p)$	L = 3459.79***
Money-Interest Rate Rule	$r = 5.01m$ $m - p = 0.40y - 1.15u$ $u = 1.35r + 0.48(m - p)$	L = 3467.34

C. Divisia MZM

Recursive	$r = 0.24y + 0.56p + 0.07cp$ $m = 0.13y + 0.36p - 0.37r + 0.01cp$	L = 3422.21
Taylor Rule with Money	$r = 0.24y + 0.64p + 1.13m$ $m - p = 0.38y - 1.30u$ $u = 1.18r + 0.44(m - p)$	L = 3416.41
Taylor Rule without Money	$r = 0.28y + 0.78p$ $m - p = 0.19y - 0.49u$ $u = 0.92r + 0.31(m - p)$	L = 3413.84**
Money-Interest Rate Rule	$r = 2.93m$ $m - p = 0.54y - 1.99u$ $u = 1.27r + 0.40(m - p)$	L = 3415.61

Note: Each panel shows the estimates of equations (11) and (12) from the recursive specification or equations (14)-(16) from the non-recursive models, together with the maximized value of the log-likelihood function L. ** or *** denotes that the null hypothesis that money can be excluded from the monetary policy rule is rejected at the 95 or 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.

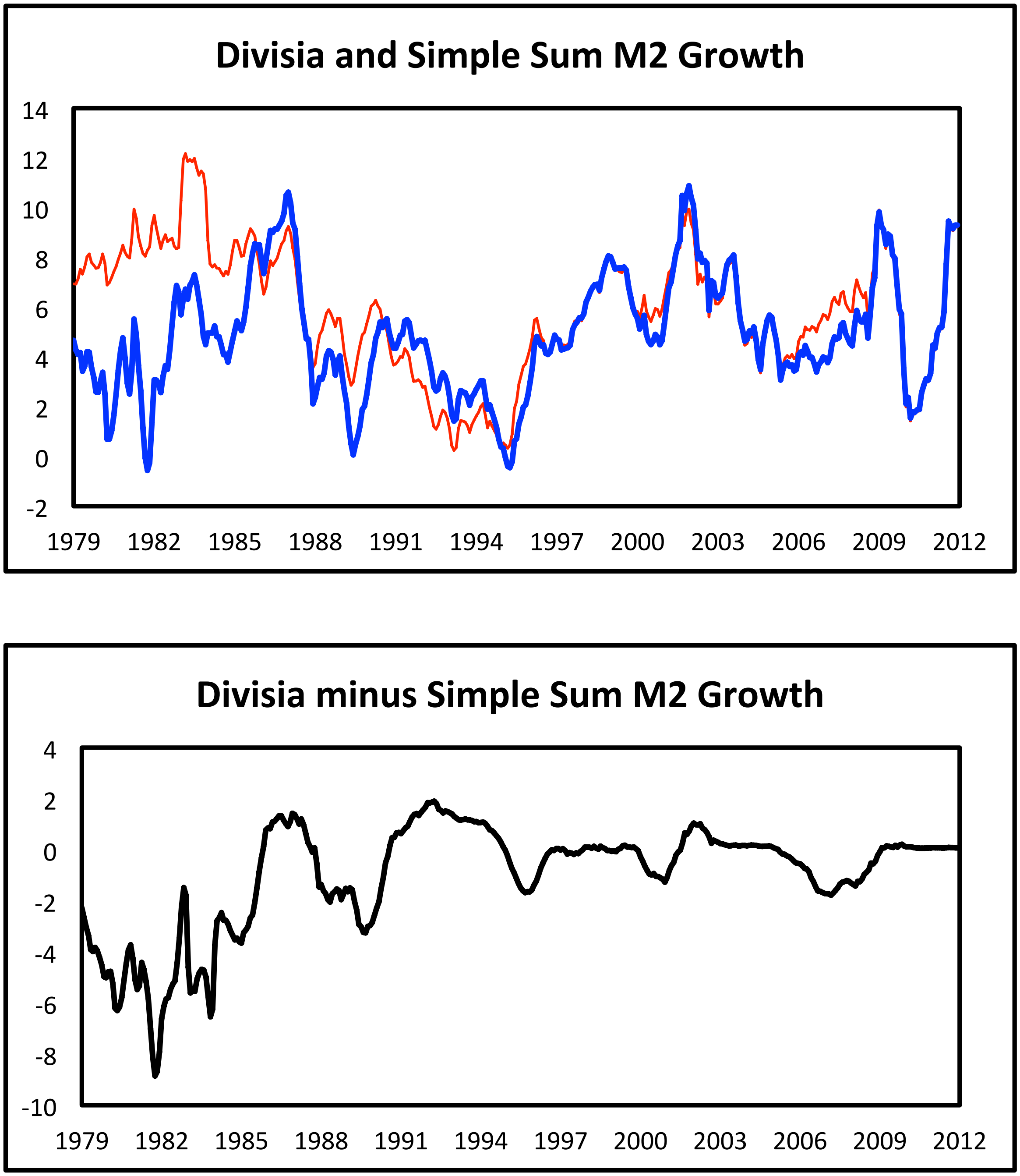
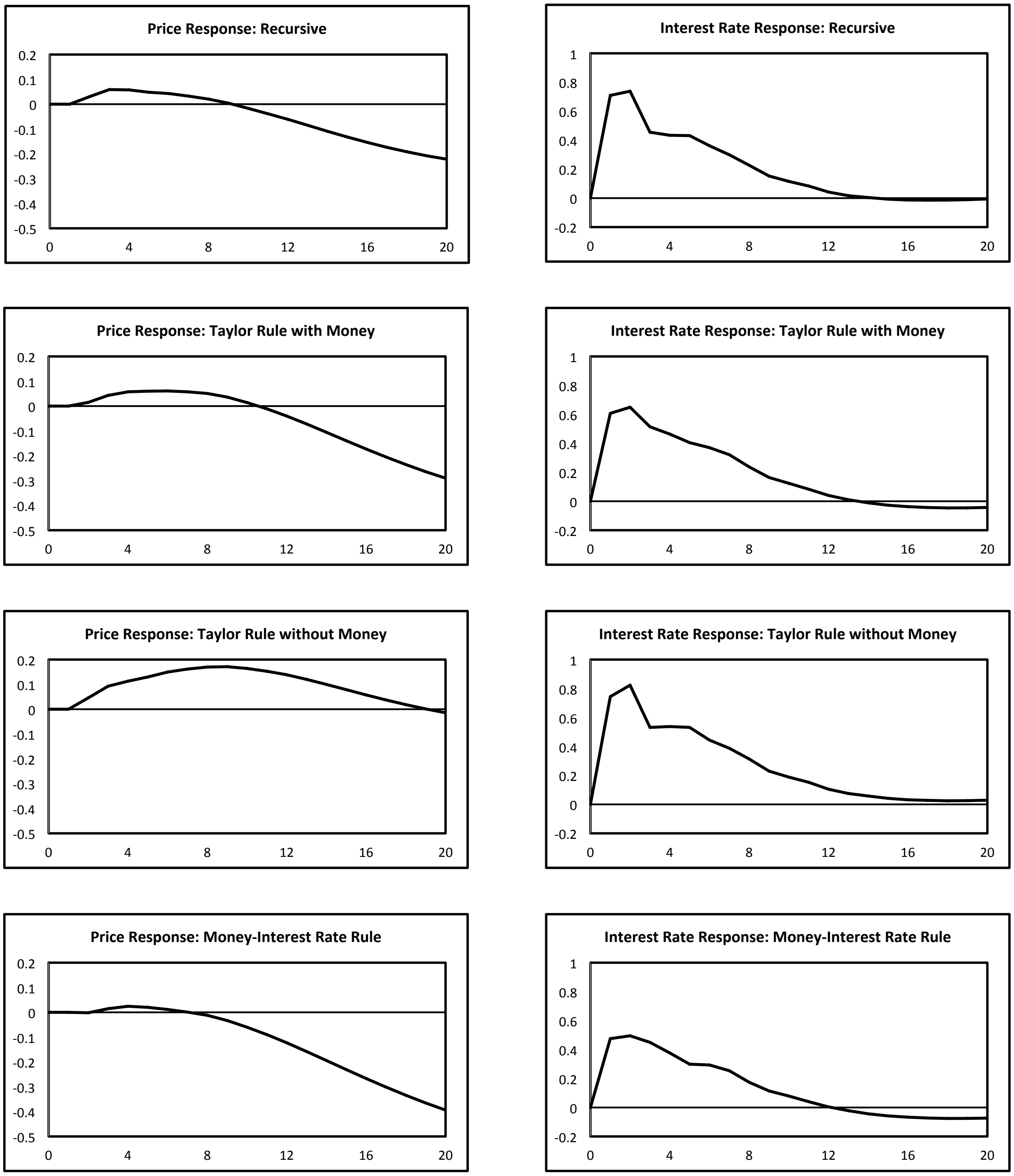


Figure 1. Divisia versus Simple Sum M2 Growth. The top panel shows year-over-year percentage growth rates of the St. Louis Fed's Divisia M2 aggregate (thick blue line) and the Federal Reserve's official simple sum M2 aggregate (thin red line). The bottom panel plots the difference between the two growth rate series.


Price Response: Recursive

Interest Rate Response: Recursive

Price Response: Taylor Rule with Money

Interest Rate Response: Taylor Rule with Money

Price Response: Taylor Rule without Money

Interest Rate Response: Taylor Rule without Money

Price Response: Money-Interest Rate Rule

Interest Rate Response: Money-Interest Rate Rule

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 St. Louis Fed's Divisia MZM monetary aggregate.

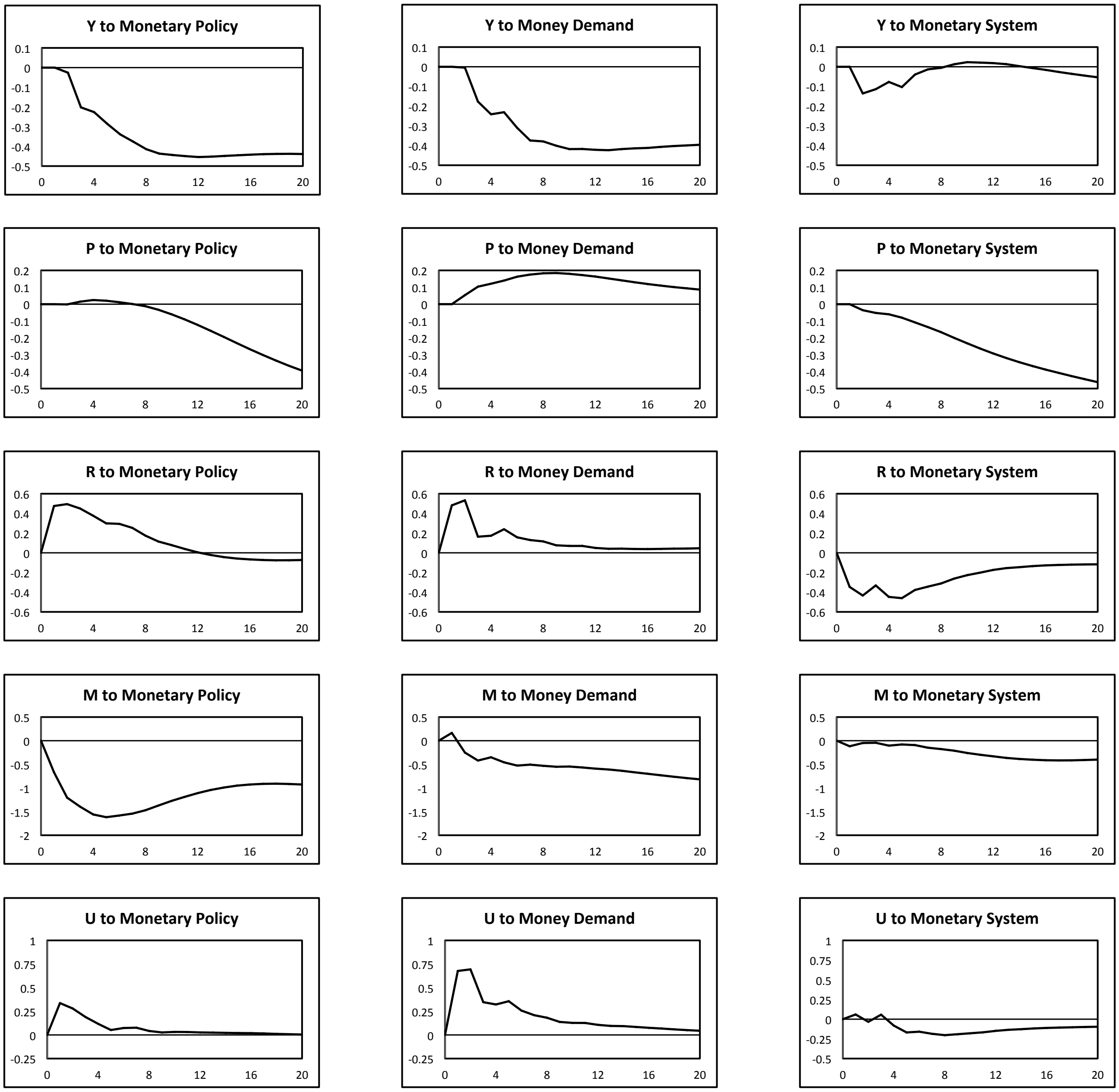

Y to Monetary Policy
Y to Money Demand
Y to Monetary System
P to Monetary Policy
P to Money Demand
P to Monetary System
R to Monetary Policy
R to Money Demand
R to Monetary System
M to Monetary Policy
M to Money Demand
M to Monetary System
U to Monetary Policy
U to Money Demand
U to Monetary System

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 St. Louis Fed’s Divisia MZM monetary aggregate.

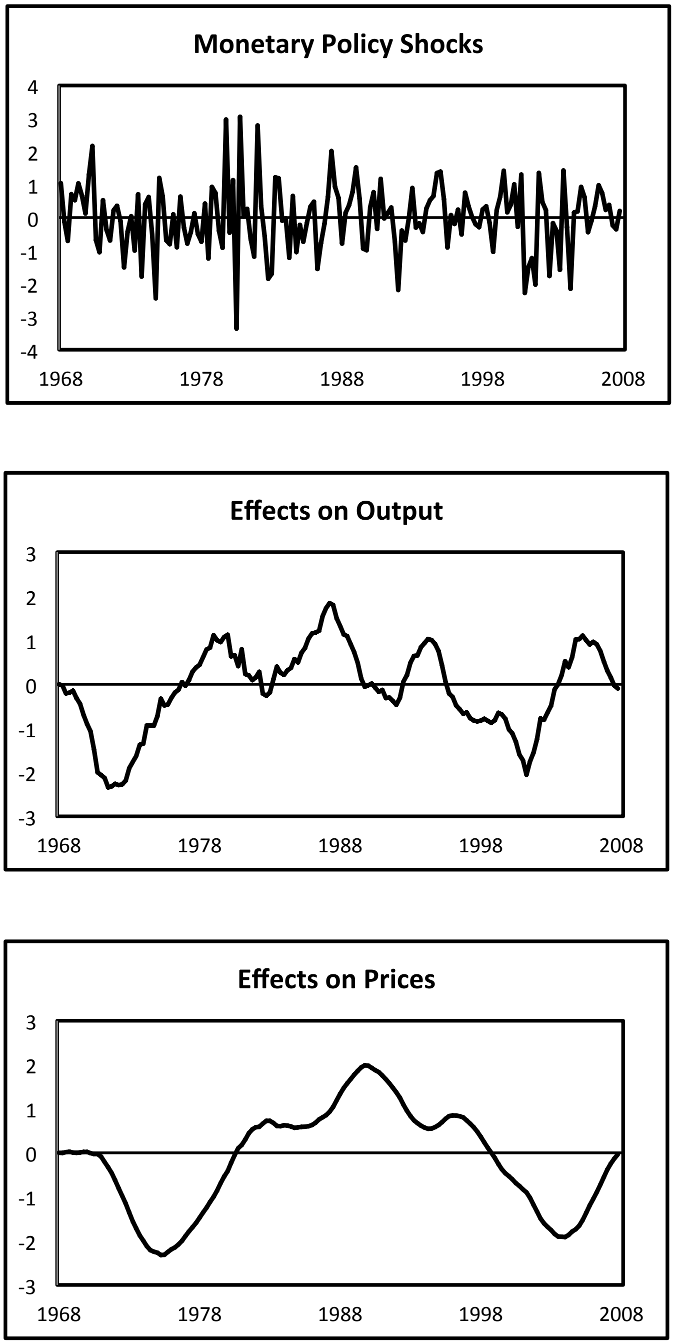


Figure 4. Monetary Policy Shocks and Their Effects. The top panel plots the serially uncorrelated monetary policy shock from structural VAR with the money-interest rate rule, estimated with data from 1967.1 through 2007.4. Money is measured by the St. Louis Fed's Divisia MZM monetary aggregate. The bottom 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.

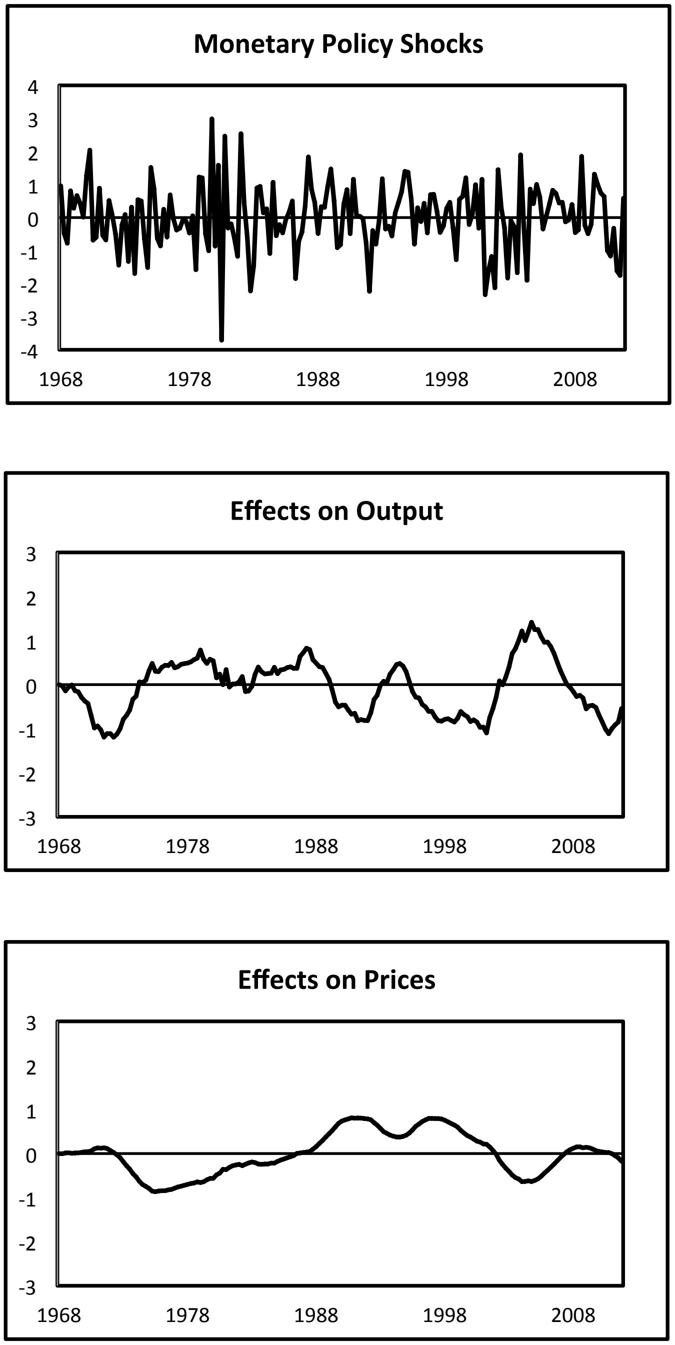


Figure 5. Monetary Policy Shocks and Their Effects. The top panel plots the serially uncorrelated monetary policy shock from structural VAR with the money-interest rate rule, estimated with data from 1967.1 through 2011.4. Money is measured by the St. Louis Fed's Divisia MZM monetary aggregate. The bottom 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.

Appendix

This appendix extends the results displayed in table 6 by reestimating the recursive and structural VARs using each from the full range of Divisia monetary aggregates provided by the Federal Reserve Bank of St. Louis and Center for Financial Stability.

Anderson and Jones (2011) at the St. Louis Fed construct Divisia monetary services indexes at five levels of aggregation. The assets included in their M1 and M2 indexes are the same as those in the Federal Reserve Board's simple sum M1 and M2 aggregates. Their M2M ("M2-minus") aggregate excludes small time deposits, which appear in the M2 aggregate; their MZM aggregate, like the St. Louis Fed's analogous simple sum MZM measure, also excludes small time deposits from M2, but adds institutional money market funds to so as to encompass the full range of monetary assets with zero maturity. Finally, their broadest Divisia monetary services aggregate, labeled "MSIALL," adds institutional money market mutual funds to M2.

Barnett, Liu, Mattson, and van den Noort (2012) at the Center for Financial Stability reconstruct Divisia indexes at the same five levels of aggregation as Anderson and Jones (2011), but using a different benchmark interest rate to compute the user cost of each individual monetary asset, which has minor effects on the quantity aggregates but leads to more noticeable differences across the series for the price duals. In addition, they construct Divisia price and quantity indexes at three higher levels of aggregation. To the list of assets included in Anderson and Jones' MSIALL aggregate they add, in succession, large denomination time deposits and repurchase agreements to obtain their Divisia M3 series, commercial paper to obtain their Divisia M4M ("M4 minus") series, and US Treasury Bills to obtain their Divisia M4 series. The assets included in Divisia M4 therefore correspond closely to those accounted for in the Federal Reserve Board's discontinued L simple sum aggregate.

Table A1. Maximum Likelihood Estimates of Structural VARs, St. Louis Fed Data

A. St. Louis Divisia M1

Recursive	$r = 0.20y + 0.41p + 0.06cp$ $m = 0.15y + 0.21p - 0.12r + 0.01cp$	$L = 3467.07$
Taylor Rule with Money	$r = -0.23y - 0.02p + 3.65m$ $m - p = 0.61y - 1.66u$ $u = 1.13r + 0.20(m - p)$	$L = 3463.70$
Taylor Rule without Money	$r = 0.25y + 0.59p$ $m - p = 0.19y - 0.18u$ $u = 0.87r + 0.10(m - p)$	$L = 3454.82$***
Money-Interest Rate Rule	$r = 2.88m$ $m - p = 0.54y - 1.44u$ $u = 1.11r + 0.22(m - p)$	$L = 3463.46$

B. St. Louis Divisia M2M

Recursive	$r = 0.23y + 0.57p + 0.07cp$ $m = 0.13y + 0.37p - 0.34r + 0.02cp$	$L = 3424.59$
Taylor Rule with Money	$r = 0.21y + 0.59p + 1.14m$ $m - p = 0.36y - 1.13u$ $u = 1.16r + 0.39(m - p)$	$L = 3419.63$
Taylor Rule without Money	$r = 0.28y + 0.79p$ $m - p = 0.19y - 0.42u$ $u = 0.93r + 0.25(m - p)$	$L = 3417.01$**
Money-Interest Rate Rule	$r = 2.55m$ $m - p = 0.48y - 1.63u$ $u = 1.24r + 0.35(m - p)$	$L = 3418.96$

C. St. Louis Divisia M2

Recursive	$r = 0.19y + 0.64p + 0.07cp$ $m = 0.13y + 0.32p - 0.20r - 0.00cp$	$L = 3474.13$
Taylor Rule with Money	$r = -0.25y - 0.07p + 6.27m$ $m - p = 0.31y - 1.23u$ $u = 1.36r + 0.46(m - p)$	$L = 3467.48$
Taylor Rule without Money	$r = 0.25y + 0.85p$ $m - p = 0.16y - 0.30u$ $u = 0.91r + 0.33(m - p)$	$L = 3459.79$***
Money-Interest Rate Rule	$r = 5.01m$ $m - p = 0.40y - 1.15u$ $u = 1.35r + 0.48(m - p)$	$L = 3467.34$

D. St. Louis Divisia MZM

Recursive	$r = 0.24y + 0.56p + 0.07cp$ $m = 0.13y + 0.36p - 0.37r + 0.01cp$	$L = 3422.21$
Taylor Rule with Money	$r = 0.24y + 0.64p + 1.13m$ $m - p = 0.38y - 1.30u$ $u = 1.18r + 0.44(m - p)$	$L = 3416.41$
Taylor Rule without Money	$r = 0.28y + 0.78p$ $m - p = 0.19y - 0.49u$ $u = 0.92r + 0.31(m - p)$	$L = 3413.84$**
Money-Interest Rate Rule	$r = 2.93m$ $m - p = 0.54y - 1.99u$ $u = 1.27r + 0.40(m - p)$	$L = 3415.61$

E. St. Louis MSIALL

Recursive	$r = 0.20y + 0.65p + 0.07cp$ $m = 0.14y + 0.31p - 0.24r - 0.01cp$	L = 3467.92
Taylor Rule with Money	$r = -0.17y + 0.31p + 6.22m$ $m - p = 0.34y - 1.45u$ $u = 1.40r + 0.54(m - p)$	L = 3460.15
Taylor Rule without Money	$r = 0.26y + 0.85p$ $m - p = 0.16y - 0.36u$ $u = 0.93r + 0.42(m - p)$	L = 3453.05***
Money-Interest Rate Rule	$r = 6.03m$ $m - p = 0.33y - 1.44u$ $u = 1.39r + 0.54(m - p)$	L = 3460.02

Note: Each panel shows the estimates of equations (11) and (12) from the recursive specification or equations (14)-(16) from the non-recursive models, together with the maximized value of the log-likelihood function L. ** or *** denotes that the null hypothesis that money can be excluded from the monetary policy rule is rejected at the 95 or 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.

Table A2. Maximum Likelihood Estimates of Structural VARs, CFS Data

A. CFS Divisia M1

Recursive	$r = 0.20y + 0.38p + 0.06cp$ $m = 0.09y + 0.21p - 0.11r + 0.01cp$	$L = 3415.06$
Taylor Rule with Money	$r = -0.06y - 0.17p + 3.93m$ $m - p = 0.41y - 0.89u$ $u = 1.68r + 0.06(m - p)$	$L = 3414.08$
Taylor Rule without Money	$r = 0.23y + 0.57p$ $m - p = 0.12y - 0.10u$ $u = 1.38r - 0.06(m - p)$	$L = 3405.37$***
Money-Interest Rate Rule	$r = 3.56m$ $m - p = 0.39y - 0.84u$ $u = 1.67r + 0.07(m - p)$	$L = 3414.06$

B. CFS Divisia M2M

Recursive	$r = 0.23y + 0.52p + 0.07cp$ $m = 0.13y + 0.28p - 0.31r + 0.02cp$	$L = 3220.84$
Taylor Rule with Money	$r = 0.15y + 0.50p + 2.22m$ $m - p = 0.42y - 0.30u$ $u = 4.69r + 0.90(m - p)$	$L = 3220.28$
Taylor Rule without Money	$r = 0.28y + 0.76p$ $m - p = 0.19y - 0.10u$ $u = 3.49r + 0.42(m - p)$	$L = 3214.95$***
Money-Interest Rate Rule	$r = 3.49m$ $m - p = 0.48y - 0.35u$ $u = 4.81r + 0.77(m - p)$	$L = 3220.05$

C. CFS Divisia M2

Recursive	$r = 0.22y + 0.56p + 0.07cp$ $m = 0.14y + 0.26p - 0.31r + 0.02cp$	$L = 3182.33$
Taylor Rule with Money	$r = 0.16y + 0.69p + 1.40m$ $m - p = 0.36y - 0.29u$ $u = 4.95r + 1.51(m - p)$	$L = 3180.78$
Taylor Rule without Money	$r = 0.26y + 0.81p$ $m - p = 0.20y - 0.11u$ $u = 3.26r + 0.63(m - p)$	$L = 3177.07$***
Money-Interest Rate Rule	$r = 2.82m$ $m - p = 0.43y - 0.37u$ $u = 5.39r + 1.26(m - p)$	$L = 3180.15$

D. CFS Divisia MZM

Recursive	$r = 0.22y + 0.58p + 0.07cp$ $m = 0.15y + 0.30p - 0.24r + 0.00cp$	$L = 3233.88$
Taylor Rule with Money	$r = -0.01y + 0.49p + 2.87m$ $m - p = 0.44y - 0.28u$ $u = 4.91r + 1.16(m - p)$	$L = 3233.17$
Taylor Rule without Money	$r = 0.26y + 0.83p$ $m - p = 0.22y - 0.09u$ $u = 3.48r + 0.61(m - p)$	$L = 3226.25$***
Money-Interest Rate Rule	$r = 3.46m$ $m - p = 0.46y - 0.30u$ $u = 4.97r + 1.09(m - p)$	$L = 3232.96$

E. CFS MSIALL

Recursive	$r = 0.21y + 0.57p + 0.08cp$ $m = 0.15y + 0.31p - 0.20r + 0.01cp$	$L = 3213.59$
Taylor Rule with Money	$r = -0.03y + 0.37p + 2.64m$ $m - p = 0.37y - 0.26u$ $u = 5.28r + 1.69(m - p)$	$L = 3212.22$
Taylor Rule without Money	$r = 0.25y + 0.83p$ $m - p = 0.20y - 0.08u$ $u = 3.22r + 0.67(m - p)$	$L = 3206.51$***
Money-Interest Rate Rule	$r = 3.02m$ $m - p = 0.38y - 0.27u$ $u = 5.36r + 1.62(m - p)$	$L = 3212.05$

F. CFS Divisia M3

Recursive	$r = 0.19y + 0.54p + 0.07cp$ $m = 0.12y + 0.19p - 0.22r + 0.02cp$	$L = 3184.95$
Taylor Rule with Money	$r = 0.02y + 0.58p + 2.72m$ $m - p = 0.33y - 0.31u$ $u = 6.00r + 2.18(m - p)$	$L = 3183.02$
Taylor Rule without Money	$r = 0.24y + 0.80p$ $m - p = 0.17y - 0.08u$ $u = 3.07r + 0.87(m - p)$	$L = 3176.98$***
Money-Interest Rate Rule	$r = 3.64m$ $m - p = 0.35y - 0.34u$ $u = 6.20r + 1.96(m - p)$	$L = 3182.74$

G. CFS Divisia M4M

Recursive	$r = 0.20y + 0.58p + 0.07cp$ $m = 0.15y + 0.26p - 0.17r + 0.02cp$	L = 3187.85
Taylor Rule with Money	$r = -0.04y + 0.40p + 2.36m$ $m - p = 0.34y - 0.28u$ $u = 5.89r + 2.58(m - p)$	L = 3184.90
Taylor Rule without Money	$r = 0.25y + 0.83p$ $m - p = 0.20y - 0.07u$ $u = 3.00r + 0.88(m - p)$	L = 3180.06***
Money-Interest Rate Rule	$r = 2.69m$ $m - p = 0.35y - 0.29u$ $u = 6.04r + 2.47(m - p)$	L = 3184.62

H. CFS Divisia M4

Recursive	$r = 0.20y + 0.56p + 0.07cp$ $m = 0.14y + 0.22p - 0.19r + 0.02cp$	L = 3179.46
Taylor Rule with Money	$r = -0.09y + 0.39p + 3.33m$ $m - p = 0.33y - 0.31u$ $u = 6.70r + 2.83(m - p)$	L = 3176.19
Taylor Rule without Money	$r = 0.25y + 0.81p$ $m - p = 0.18y - 0.07u$ $u = 3.14r + 1.27(m - p)$	L = 3170.42***
Money-Interest Rate Rule	$r = 3.54m$ $m - p = 0.33y - 0.31u$ $u = 6.75r + 2.76(m - p)$	L = 3175.95

Note: Each panel shows the estimates of equations (11) and (12) from the recursive specification or equations (14)-(16) 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.