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FRIEDMAN AND SCHWARTZ REVISITED

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ABSTRACT

More than fifty years ago, Friedman and Schwartz examined historical data for the United States and found evidence of pro-cyclical movements in the money stock, which led corresponding movements in output. We find similar correlations in more recent data; these appear most clearly when Divisia monetary aggregates are used in place of the Federal Reserve's official, simple-sum measures. When we use information in Divisia money to estimate a structural vector autoregression, identified monetary policy shocks appear to have large and persistent effects on output and prices, with a lag that has lengthened considerably since the early 1980s.

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1. MONEY AND BUSINESS CYCLES: INTELLECTUAL TRENDS AND DATA PROBLEMS

More than fifty years ago, Friedman and Schwartz (1963a) presented statistical evidence that pro-cyclical movements in the money supply exhibited a two-quarter lead over corresponding movements in output. They interpreted this evidence as indicative of a causal role for changes in the money stock in generating fluctuations in output and offered a verbal account of how, theoretically, this link between money and the business cycle might come about. Friedman and Schwartz's (1963b) *Monetary History of the United States*, especially its most famous chapter, on the Great Depression, provided further evidence that monetary instability can be, and in fact has been, an important source of real instability in the American economy.[1]

Less than ten years later, at the beginning of a methodological revolution in the field, Lucas (1972) showed how a link between monetary and real instability also could appear in a dynamic, stochastic, general equilibrium model, thereby translating Friedman and Schwartz's message into what became the language of modern macroeconomics. Theoretical interest in monetary sources of economic fluctuations faded in the decades that followed, however. For example, Kydland and Prescott's (1982) real business cycle model built closely on Lucas' earlier work by describing aggregate fluctuations as the outcome of optimizing behavior by consumers and firms possessing rational expectations and operating in a fully dynamic and stochastic environment. This model, however, delivered a very different substantive message by showing how key features of postwar business cycles could be explained within a framework that makes no reference to money or indeed to nominal variables at all. More recently, New Keynesian models, like those presented in textbooks such as Woodford (2003), have reintroduced a role for monetary policy in stabilizing or destabilizing the economy while retaining many basic features of the real business cycle framework. Strikingly, however, measures of the money supply remain well behind the scenes in these newest monetary models for, as explained by Ireland (2004), monetary policy in most New Keynesian analyses is described fully by its implications for interest rates, with no separate channel for changes in the money stock to influence aggregate fluctuations.[2] More than thirty years have passed, therefore, since correlations between the nominal money supply and real output like those reported by Friedman and Schwartz (1963a) have received attention from leading business cycle theorists.[3]

Meanwhile, over the same thirty-year period, empirical work in the tradition of Friedman and Schwartz has been hindered greatly by difficulties in constructing accurate measures of flows of monetary services that, according to economic theory, are most likely to reflect their hypothesized relationships between money, output, and prices. In 1980, Barnett (1980) demonstrated that simple-sum monetary aggregates, including the Federal Reserve's official M1 and M2 series, mis-measure the true flow of monetary services generated in an economy where agents have the willingness and ability to substitute between different liquid assets, some of which may pay interest and some of which may not, but all of which can be used to facilitate at least some transactions. Barnett proposed alternative, Divisia monetary aggregates that, under a wide range of circumstances, track changes in the flow of monetary services much more accurately. To illustrate the important role of measurement on inference, both Belongia (1996) and Hendrickson (2014) found that simply replacing the official simple-sum measures with their Divisia counterparts suffices to overturn previous empirical results that suggested that fluctuations in the money supply can be safely ignored in business cycle analysis.

Measurement problems associated with the official measures deepened in the 1990s when, as described by Cynamon, Dutkowsky, and Jones (2006), the Federal Reserve began allowing banks to evade statutory reserve requirements through the use of computerized programs that automatically sweep, or reclassify for internal accounting purposes, funds on deposit in customers' checking accounts into savings accounts. Because the former are included in M1 and the latter in M2, this reclassification of deposits will affect the official numbers, but the Fed's definition of M1 fails to make any adjustment for this phenomenon. As a result, a modest institutional change has introduced massive distortions into the official monetary statistics themselves. These changes, however, remain invisible to virtually all bank customers and therefore have done little if anything to change the demand for monetary assets.

In this paper, we come back full circle to the issues raised by Friedman and Schwartz (1963a), in order to reconsider the possible linkages between monetary and real instability that they first explored. It is possible for us to do this because alternatives to the Federal Reserve's official, simple-sum M1 and M2 measures have become available. These data use Barnett's (1980) procedures to aggregate the values of diverse monetary assets and correct, as well, for the purely statistical effects of sweep programs. These superlative indexes of money have very recently been constructed and made publicly available by Barnett and his associates at the Center for Financial Stability in New York. These new monetary aggregates, described by Barnett *et al.* (2013), are what we use here, first to re-compute the correlations between money and the business cycle previously seen and discussed by Friedman and Schwartz and then to interpret those correlations more fully with the help of a structural vector autoregressive time series model.[4] Beyond our attempt to re-visit the core hypothesis of Friedman and Schwartz, use of these data offers additional evidence on the effects of measurement on inference.[5]

We begin, in Section 2 below, by taking an initial look at the data and by comparing, in particular, the historical behavior of the new Divisia monetary aggregates with the behavior of the Federal Reserve's official, simple-sum measures of the money supply. In Section 3, we examine raw correlations between the cyclical components of money, output, and prices, isolated using Baxter and King's (1999) band-pass filter, which we view as providing the modern, time-series analog to the reference-cycle methodology used by Friedman and Schwartz (1963a) for much the same purpose. We find and discuss evidence of strong correlations between money and output and money and prices, particularly when our full sample of data is split into three subsamples: the first covering the period of the "Great Inflation" and "stop-go" monetary policy from 1967 through 1983, the second corresponding to the "Great Moderation" of 1984 through 1999, and the third and most recent covering the years from 2000 through 2013 leading up to, including, and following the financial crisis and "Great Recession" of 2007-2009. We show that these correlations appear strongest when the cyclical components are computed by passing the logarithm of each series through the Baxter-King filter, and are blurred when, instead, logarithmic differences are taken to convert the series into growth rates. Additionally, we present evidence consistent with the Barnett Critique, by showing that the Divisia measures of money are more closely linked to movements in output and prices than are their more commonly-used, simple-sum counterparts.[6] Finally, we show that the lags between movements in money and subsequent movements in output and prices, appear to have lengthened considerably since 1984 – a finding that echoes Batini and Nelson's (2001) while also extending it to include the most recent data.

In Sections 4 and 5, we offer a deeper interpretation of the purely reduced-form evidence presented earlier, in Section 3, by formulating and estimating a structural vector autoregression with the help of the new Divisia monetary data. Building on earlier work by Leeper and Roush (2003), we employ identifying assumptions that allow for simultaneous movements in both interest rates and money following a monetary policy shock. By using a Divisia monetary measure in place of Leeper and Roush's simple sum aggregate, however, we are also able to exploit information in the Divisia price dual to our monetary quantity aggregate in order to draw an even sharper distinction between the model's money supply and money demand relations. Impulse responses generated with from the structural VAR associate monetary policy shocks not only with movements in the federal funds rate, but also with strong and persistent movements in the Divisia monetary aggregate, which are then followed by changes in output and, with a longer lag, the aggregate price level as well. Our estimated VAR attributes to monetary policy shocks surprisingly large portions of the volatility in real GDP across all three subsamples: 1967-1983, 1984-1999, and 2000-2013. Moreover, for the early and most recent subsamples, though not for the middle period covering the Great Moderation, the estimated model links monetary policy shocks to substantial volatility in the aggregate price level too. Finally, by incorporating the Divisia monetary aggregate and its corresponding user-cost dual into the VAR, we are able to suggest why more conventional, recursive identification schemes may underestimate the role of monetary policy in generating output and price-level volatility: When we re-estimate our VAR using a recursive ordering, it re-classifies much of that volatility as the product of shocks to money demand, instead of money supply. We conclude with some thoughts on how these quantity-theoretic findings, which update and extend Friedman and Schwartz's, might be reconciled with popular models of the monetary transmission mechanism.

2. A FIRST LOOK AT THE DATA

In all that follows, we characterize and consider statistical relationships linking various measures of the money supply to real GDP as a measure of aggregate output and to the GDP deflator, as well, as a measure of the aggregate price level. The Federal Reserve's current M1 monetary aggregate, computed as the simple sum of the values of funds held in the form of currency, travelers' checks, demand deposits, and NOW accounts, resembles most closely the narrower measure of money used by Friedman and Schwartz (1963a), which included currency and demand deposits. Over the period since 1981, when NOW accounts became available nationwide and paid interest, however, simple-sum M1 became vulnerable to the Barnett (1980) Critique. Moreover, since 1990, the official M1 statistics are badly distorted by the effects of the sweep programs described by Cynamon, Dutkowsky, and Jones (2006). Thus, in addition to the official, "simple-sum M1" series, we also examine the behavior of the Divisia M1 aggregate constructed by Barnett *et al*. (2013), which also adds back to the official statistics an estimate of funds transferred from checking to savings accounts by automated sweep programs.

In addition to the M1 aggregates, we consider the Federal Reserve's official M2 aggregate, which adds to M1 the value of funds held in savings deposits (including money market deposit accounts), small time deposits (certificates of deposit with value less than $100,000), and retail (non-institutional) money market mutual fund shares; we also examine the Divisia M2 counterpart from the Center for Financial Stability. Simple-sum M2 resembles most closely Friedman and Schwartz's (1963a) broader monetary aggregate, which included currency, demand deposits, and time deposits. Finally, we report results for the MZM aggregate first proposed by Motley (1988). This measure of "money, zero maturity" subtracts the small time deposit component from M2 but adds institutional money market mutual fund shares to form an aggregate of monetary assets that all serve, at least to some extent, as a medium of exchange. MZM is reported in simple-sum form by the Federal Reserve Bank of St. Louis; the Divisia version of this aggregate is also described by Barnett *et al*. A recent study by Sustek (2010) reports positive correlations between simple-sum MZM and real GDP in samples of U.S. data before and after 1979; we extend this analysis by considering the Divisia variant of the MZM aggregate as well and by including data through the financial crisis, Great Recession, and slow recovery that has followed.

All of our data are quarterly, to match the frequency with which the series for real GDP and the GDP deflator are available. Their starting date of 1967:1 is dictated by the availability of the Divisia monetary aggregates, but also means that our sample commences after Friedman and Schwartz's (1963a) ends, allowing our analysis to be fully complementary to theirs. The data run through 2013:4 and incorporate the comprehensive revisions to the National Income and Product Accounts that accompanied the release of second-quarter 2013 real GDP.

Figure 1 plots differences between year-over-year growth rates in the Divisia and simple-sum measures of M1 and M2. Deviations as large as four percentage points in either direction appear repeatedly, for both monetary aggregates, over the entire sample period and, on occasion, the divergence between simple-sum and Divisia measures exceeds eight percentage points. These graphs highlight the empirical relevance of Barnett's (1980) critique of simple-sum monetary aggregation and echo the findings in Belongia (1996) and Hendrickson (2014) that "measurement matters" for empirical work in monetary economics.[7]

Friedman and Schwartz (1963a) separated cyclical from secular movements in the money stock by taking logarithmic first differences – hence, growth rates – of their money supply series and then employing a reference cycle methodology adapted from Burns and Mitchell (1946). Here, we take a more modern approach by passing the logarithm of each series in levels through the band-pass filter described by Baxter and King (1999). This procedure isolates the cyclical components of the data, which they define as those exhibiting fluctuations over periods ranging from six through 32 quarters.[8] As discussed by Baxter and King, the exact band-pass filter of this kind requires an infinite sample of data; we follow their recommendation by approximating the ideal filter with one that uses a two-sided, weighted average of twelve quarterly leads and lags, implying that each filtered series runs from 1970:1 through 2010:4. Figure 2 plots four of these: For two measures of money – Divisia M1 and M2 – and for output and prices. Graphically, both monetary measures seem to follow procyclical patterns like those seen by Friedman and Schwartz, with movements in money exhibiting a noticeable lead over corresponding movements in output and an even longer lead over cyclical movements in prices. The rest of our analysis aims to characterize and interpret these patterns in more detail.

3. CORRELATIONS BETWEEN THE CYCLICAL COMPONENTS OF MONEY, OUTPUT, AND PRICES

3.1 The Full Sample: 1967 – 2013

Table 1 takes a first step in quantifying the relationships illustrated graphically in Figure 2 by reporting the correlations between the cyclical component of each monetary aggregate and the cyclical component of either output or prices, contemporaneously and when money is lagged from one through 16 quarters.[9] Overall, the numbers suggest that the links between money and the business cycle, though still present, may have weakened somewhat since Friedman and Schwartz studied them. For money and output, the correlations shown in panel A always are larger for the Divisia aggregate than they are for the simple-sum measure and peak for the Divisia figures between 0.33 and 0.45 when money is lagged by four quarters. For money and prices, the correlations in panel B are again larger for the Divisia aggregates compared to the simple-sum counterparts, peaking between 0.39 and 0.68 when money is lagged by ten to 13 quarters. As we are about to see, however, these full-sample correlations – positive, but not overwhelmingly strong – mask important changes that appear across different episodes when the dataset is partitioned to reflect likely changes in institutions and policy regimes.

Before moving on, however, we also present in Table 1 for the sake of comparison the same correlations re-computed when logarithmic first differences – that is, growth rates – of each series are used in place of the band-pass filtered data. For all monetary aggregates, the correlations between money growth and real GDP growth shown in panel C are distinctly weaker than the corresponding correlations between the band-pass filtered series shown in panel A. And with the sole exception of simple-sum M2, the correlations between money growth and GDP price inflation shown in panel D are much smaller than those between the band-pass filtered series in panel B. This result recurs throughout our analysis: The connections between money, output, and prices appear much stronger when the logs of these series are expressed in levels than they do when the logs are first differenced.

We are by no means the first to notice patterns such as these. As Baxter and King (1999) explain, taking first differences amounts to passing the data through a filter that places most of its weight on the very high frequencies, producing a series that bears little resemblance to the cyclical component isolated with their preferred band-pass filter that lets through only those frequencies that correspond to periods between six and 32 quarters. Indeed, Figure 2 and panels A and B of Table 1 suggest that movements in money tend to be followed by movements in output and prices, but only after lags ranging from one to three years. By contrast, the contemporaneous correlations between money and output appear small in panel A of Table 1, and the correlations between money and prices remain strongly *negative* even when money is lagged by as many as four or five quarters. Evidently, first differencing the series focuses our attention on frequencies that are too high to capture the full effects that monetary policy has on the economy. In related work, Christ (1993) and Cochrane (2012) argue that high-frequency measurement error, when amplified by the first-difference filter, often can mask true relationships between macroeconomic variables, which are seen more clearly when the data are expressed in log levels instead. The results here, if interpreted as shedding light on the effects of changes in the money supply, provide another example to complement the work of Christ and Cochrane, which focuses instead on the properties of money demand.[10]

3.2 The Early Subsample: 1967 – 1983

Table 2 reports the same correlations in the same format as Table 1, but when they are re-computed after the sample is limited to the period from 1967:1 through 1983:4. This early subsample covers the period of rising inflation and "stop-go" monetary policy that ended with the Volcker disinflation and coincident recessions of 1980 and 1981-1982. The top panel shows much stronger correlations between all measures of money and output at much shorter lags of only one to three quarters. Even for this early subsample, the Divisia aggregates are more highly correlated with output than the simple-sum measures. Across the board, however, the money-output correlations for this early subsample are about twice as large as they appear in the full sample, with peaks of 0.70 through 0.85 all occurring within the first year.

Table 2 also shows a tighter statistical relation between cyclical movements in money and prices. The largest correlations are again for the Divisia aggregates, which peak between 0.80 and 0.88 when money is lagged by nine to thirteen quarters. Moreover, as in Table 1, Table 2 shows that the correlations diminish noticeably when the data are expressed in growth rates instead of filtered log-levels. For this first subsample, however, they still remain sizable even in the bottom two panels where, for instance, the peak correlations between Divisia money growth and output growth at all levels of aggregation exceed 0.50 and the correlations between Divisia money growth and price inflation range from 0.36 to 0.48. These are only correlations, of course, computed without reference to any specific, structural model. Yet their strength certainly is indicative of *some* link between money and both output and prices. And the lead displayed by money over both output and prices is at least suggestive of a causal role for money in generating business cycles during the 1970s and early 1980s similar to that proposed by Friedman and Schwartz (1963a) based on the same patterns that appear in the much earlier data.

3.3 The Middle Subsample: 1984 - 1999

Our second subsample covers the period from 1984 through 1999: The era of remarkable stability in the U.S. economy that became known as the Great Moderation. Although there is general agreement across studies such as Kim and Nelson (1999), McConnell and Perez-Quiros (2000), and Stock and Watson (2002) that this period of macroeconomic stability began in 1984, following the recovery from the disinflationary recessions of the early 1980s, no consensus has yet emerged to identify even an approximate ending date for the Great Moderation. Here, we terminate the subsample in 1999 mainly so as not to shorten still further our final and most recent subsample, which necessarily ends in 2013. Taylor (2009) argues, however, that the Fed began to destabilize output and prices as early as 2000 with persistent deviations from the rule-like behavior he documented earlier, in Taylor (1993). The 1999 ending date for this second subsample also will allow us to evaluate Taylor's argument further, when we focus later on the most recent data.

The two panels on the right-hand side of Figure 2 clearly show diminished volatility in both output and prices during the years from 1984 through 1999, while the two panels on the left-hand side just as clearly show signs of *increased* volatility in the Divisia M1 aggregate. These are signs that the relationships between money, output and prices shifted after the Volcker disinflation. Perhaps, for this very reason, both real business cycle and New Keynesian theories developed during that time paid little attention to the behavior of the money supply.

Further signs appear in Table 3, where the correlations for this period are typically smaller than their counterparts from Table 2. Still, there are several details worth mentioning. First, in virtually all cases in which the variables are expressed in filtered log-levels, the correlations between the Divisia monetary aggregates and either output or prices are noticeably higher than those between the simple-sum aggregates and the same macroeconomic variable. As emphasized by Belongia (1996) and Hendrickson (2014), business cycle theorists might not have been so quick to dismiss information contained in the monetary aggregates if they had been looking at the more reliable Divisia series.[11] Second, while the correlations shown in Table 3 for this middle subsample are smaller than those in Table 2 for the earlier period, they typically remain *larger* than the ones from the full sample reported in Table 1. These results indicate that splitting the sample to reflect changes in monetary policy and/or changes in the structure of the American economy before and after 1984 matters, considerably, in gauging the importance of money as a business cycle indicator. Focusing on the entries for the Divisia aggregates in filtered log-levels, the peak correlations between money and output range from 0.41 to 0.45 and the peak correlations between money and prices range from 0.45 to 0.79. There certainly is more noise in the money supply during the Great Moderation, but not enough to completely obscure relations to macroeconomic fluctuations.

Third and finally, the lead of money over output and prices lengthens considerably during this middle subsample, with peak money-output correlations appearing when money is lagged by six to eight quarters and peak money-price correlations when money is lagged by 13 to 14 quarters. Batini and Nelson (2001), similarly, find peak correlations between money growth and inflation at lags that lengthen after 1980. In fact, their value of 0.71 for the peak correlation between year-over-year simple-sum M2 growth and twelve-month consumer price inflation between September 1986 and August 2001 essentially matches the peak correlation of 0.70 shown in panel D of our Table 3 for the correlation between simple-sum M2 growth and GDP price inflation for this 1984:1 – 1994:4 period, though Batini and Nelson find that this peak correlation comes at an even longer lag – of 49 months – than we do.

3.4 The Recent Subsample: 2000 – 2013

At least two obstacles immediately confront any researcher who explores the role of money and monetary policy in either ameliorating or exacerbating the Great Recession of 2008 and the slow recovery experienced since then. The first has to do with the limited time frame under consideration. Moreover, it is not clear whether the initial slowdown in 2007, the rapid intensification of the downturn in the second half of 2008, and the sluggish recovery since mid-2009 are separate events, with distinct causes, or all the product of one single, large disturbance. In the latter case, there is in effect only one observation to work with, but even in the former, statistical analysis will be difficult as the effects of any individual cause are likely to be blurred together with those of others. Second, the potential for money demand instability to distort statistical relations between money, output, and prices always has been the Achilles heel of monetarist analyses; this difficulty would seem to loom especially large before, during, and after the financial crisis of 2008 – the most severe of its kind since the Great Depression. This problem arises because shifts in the demand for liquid assets by banks and other financial institutions, non-bank corporations, and households could have occurred once or on several separate occasions during the last six years. To cite once more the most striking but potentially misunderstood example: The quantity of reserves supplied to the banking system, as reported by the Federal Reserve in its H.3 statistical release, increased from slightly less than $46 billion to over $2.5 trillion – hence, by a factor of more than 50 – between August 2008 and December 2013. However, the Federal Reserve also began paying interest on reserves during that period. As explained by Ireland (2014), the dramatic increase in the equilibrium quantity of reserves most likely represents, in large part if not entirely, an increase in the *demand* for reserves that the Fed then accommodated with an increase in supply, as opposed to an autonomous increase in supply that would have led to a similarly dramatic increase in broader measures of money and, from there, movements in output and inflation.[12]

Nevertheless, all measures of money exhibit unusual – and volatile – behavior since 2000. The two panels of Figure 3, for instance, plot year-over-year growth rates of Divisia M1 and M2, focusing specifically on the recent subsample. Unlike the filtered data that must terminate three years before the full sample ends, these smoothed quarterly growth rate series can be computed through 2013:4. Nonetheless, this alternative transformation of the data creates series that behave quite similarly to the band-pass filtered series shown in Figure 2. Divisia M1 growth, in particular, peaked in the first half of 2004 and followed a sharp downward trajectory through the beginning of 2008. This measure of money bounced back in late 2008, but then resumed its downward trend in 2009 before recovering once again. With regard to the Federal Reserve's large scale asset purchase programs, known popularly as "quantitative easing," note that the figure also indicates that both measures of money declined sharply during much of the period of QE1, increased during the brief QE2 episode, and have been largely flat or declining throughout QE3. Among the lessons of this figure is that gauging the stance of monetary policy by the level of interest rates or the size the Federal Reserve's balance sheet alone can be misleading, as neither the reductions in the federal funds rate target between 2007 and 2008 nor the less conventional policy actions undertaken since then have led consistently to accelerations in money growth.

Is it merely an illusion that these movements in money appear to presage similar movements in real GDP? To see more clearly, Table 4 reports the correlations, computed with data from the period starting in 2000:1 and ending in 2013:4, hence covering the lead-up to, intensification of, and slow recovery from, the Great Recession of 2008. For this most recent episode, the peak correlations between money and output occur at even longer lags than for the Great Moderation: With M1, output is most highly correlated when money is lagged by eight quarters, and with the broader M2 and MZM aggregates, the largest correlations appear when money is lagged by 11 to 14 quarters. On the other hand, the magnitudes of the peak money-output correlations also increase markedly, ranging from 0.72 to 0.84 and thereby nearly match the very high correlations seen previously for the 1967-1983 subsample. The lag required to find the highest correlations between money and prices lengthens as well, but most of the numbers reported in the second panel of Table 4 are even *larger* than they were in Table 2 for the earliest, pre-1983 subsample.

Particularly noteworthy are the correlations between Divisia M1 and both output and prices, in filtered log-levels, since 2000. The correlation between real GDP and Divisia M1 lagged eight quarters is 0.84; the correlation between the GDP deflator and Divisia M1 lagged 12 quarters is 0.88. By way of comparison, King and Watson (1996), using data running from 1947 through 1992 and a lag of six quarters, find that the nominal interest rate on Treasury bills is a strong, inverse leading indicator, having a correlation coefficient of −0.74 with output. Here, in the most recent data, Divisia M1 appears to be an even stronger leading indicator for both output and prices.

4. TOWARD A MORE COMPLETE MODEL OF MONEY AND THE BUSINESS CYCLE

Although the correlations between money and output and money and prices reported in Tables 1 through 4 are, by themselves, no more than reduced-form statistical relationships, their strength and prevalence cry out for a structural interpretation. Here, we take the next step towards building a complete, dynamic, stochastic, general equilibrium model of money and the business cycle by using a modest amount of economic theory to trace these correlations back to monetary policy disturbances, identified within a vector autoregressive time series framework.

Our VAR describes the behavior of six variables. The first three come straight from our reduced-form analysis: output Y_t as measured by real GDP, the price level P_t as measured by the GDP deflator, and money M_t as measured by Divisia M1. Adding the short-term nominal interest rate R_t, measured by the effective federal funds rate, to the list allows us to draw links between our results and those from the voluminous literature that follows Bernanke and Blinder (1992); associating monetary policy disturbances with statistical innovations to the funds rate also will reassure readers that the important role that our analysis assigns to the money stock is not simply due to the exclusion of interest rates from the framework. Adding the Divisia M1 user cost U_t, measured by the price dual to the Divisia M1 quantity index and, likewise, made available by Barnett and his associates at the Center for Financial Stability, helps greatly, as explained below, in distinguishing shocks to the money supply from those to money demand. Finally, following the standard practice established by Sims (1992), we include in the VAR a measure CP_t of commodity prices – the CRB/BLS spot index compiled by the Commodity Research Bureau – as well. To derive our benchmark results, we follow standard practice in the literature on structural VARs, by letting output, the price level, money, and commodity prices enter the model in log-levels, while expressing the federal funds rate and Divisia user cost measures as decimals and in annualized terms so that a federal funds rate conventionally quoted at an annual rate of 5 percent, for example, appears in our quarterly dataset as a reading of $R_t = 0.05$.[13] As in Tables 1-4, however, we also experiment with alternative specifications in which logarithmic first differences – hence, output growth, inflation, money growth, and commodity price inflation – appear in the VAR together with the funds rate and Divisia user cost in decimals.

Stacking the variables at each date into the 6 x 1 vector

$$X_t = [P_t \quad Y_t \quad CP_t \quad R_t \quad M_t \quad U_t]', \tag{1}$$

the structural model takes the form

$$AX_t = \mu + \sum_{j=1}^{q} \Phi_j X_{t-j} + \Sigma \varepsilon_t, \tag{2}$$

where A is a 6 x 6 matrix of coefficients with ones along the diagonal, μ is a 6 x 1 vector of constant terms, each Φ_j, $j = 1, 2, ..., q$, is a 6 x 6 matrix of slope coefficients, Σ is a 6 x 6 matrix with standard deviations of the structural disturbances along its diagonal and zeros elsewhere, and ε_t is a 6 x 1 vector of serially and mutually uncorrelated structural disturbances, normally distributed with zero means and

$$E\varepsilon_t\varepsilon_t' = I. \tag{3}$$

The reduced form associated with equations (2) and (3) is

$$X_t = \nu + \sum_{j=1}^{q} \Gamma_j X_{t-j} + x_t, \tag{4}$$

where the constant term $\nu = A^{-1}\mu$ is 6 x 1, each $\Gamma_j = A^{-1}\Phi_j$, $j = 1, 2, ..., q$, is a 6 x 6 matrix of slope coefficients, and the 6 x 1 vector of zero mean disturbances x_t is such that

$$Ex_t x_t' = \Omega. \tag{5}$$

Comparing equations (2) and (3) to equations (4) and (5) reveals that the structural and reduced-form disturbances are linked via

$$A^{-1}\Sigma\varepsilon_t = x_t,$$

so that

$$A^{-1}\Sigma\Sigma'(A^{-1})' = \Omega. \tag{6}$$

Equation (6) highlights the familiar identification problem: Since the covariance matrix Ω for the reduced-form innovations has only 21 distinct elements, at least 15 restrictions must be imposed on the 36 elements of A and Σ that have not been normalized to equal zero or one in order to identify the structural disturbances from the information in the reduced form.

One popular approach to solving this identification problem follows Sims (1980) by requiring A to be lower triangular. Here, with the variables ordered as shown in equation (1), if the fourth element of ε_t is interpreted as a monetary policy shock ε_t^{mp}, this triangular 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 same variables according to the relationship

$$a_{41}P_t + a_{42}Y_t + a_{43}CP_t + R_t = \sigma_{44}\varepsilon_t^{mp}, \tag{7}$$

where a_{ij} denotes the coefficient from row i and column j of A and σ_{44} is the fourth element along the diagonal of Σ, and where, for simplicity, terms involving the constant μ and lagged values X_{t-j} in equation (2) are suppressed in equation (7) to focus on the contemporaneous links between variables. Although it also includes commodity prices in the list of variables to which the Fed responds, equation (7) bears a striking resemblance to the monetary policy rule proposed by Taylor (1993), through which the Fed adjusts its setting for the federal funds rate in response to changes in aggregate prices and output. Likewise, and again ignoring the constant and lagged terms that appear in equation (2), the fifth row of the triangular model takes the form

$$a_{51}P_t + a_{52}Y_t + a_{53}CP_t + a_{54}R_t + M_t = \sigma_{55}\varepsilon_t^{md}, \tag{8}$$

which can be interpreted as a flexibly-specified money demand equation, linking the demand for monetary services to the price level, output, commodity prices, and the short-term interest rate as the opportunity cost of holding money. Thus, while the triangular identification scheme is based mainly on assumptions of how quickly each variable in equation (1) responds to shocks to the others, these assumptions also can be interpreted following Leeper and Roush (2003), in terms of the restrictions they place on the elasticities of money supply and demand. In particular, equations (7) and (8) depict the Fed as targeting the funds rate without reference to changes in the stock of money; instead, the money stock expands or contracts so as to accommodate fully shifts in money demand, given the central bank's interest rate target.

Our preferred, alternative identification scheme, motivated by the correlations found in Tables 1-4, allows for a larger role for the money stock in the making and transmission of monetary policy.[14] In particular, by imposing a combination of zero restrictions and linear constraints, we allow A to take the non-triangular form

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} \\ 0 & 0 & 0 & 1 & a_{45} & 0 \\ -1 & a_{52} & 0 & 0 & 1 & a_{56} \\ -a_{65} & 0 & 0 & a_{64} & a_{65} & 1 \end{bmatrix}. \tag{9}$$

The first two rows in equation (9) identify a set of non-monetary disturbances through the same timing assumptions reflected in the triangular scheme, in which aggregate prices and output respond only after a one-period lag to other shocks hitting the economy. In our analysis, which uses quarterly data, these timing assumptions become stronger than if monthly data are employed instead. However, the often-lengthy lags between movements in money and corresponding movements in output and prices implied by the correlations in Tables 1-4 suggest that they remain reasonable. Especially for the middle and recent subsamples, most of the contemporaneous correlations between money and output and money and prices are negative, more likely reflecting the response of monetary policy to changes in the economy than the response of the economy to changes in monetary policy. Row three of equation (9), meanwhile, assumes that commodity prices react immediately to every shock hitting the economy.

To model the monetary system in more detail, the last three rows of equation (9) draw more heavily on theory. Row four describes a monetary policy rule of the form

$$R_t + a_{45}M_t = \sigma_{44}\varepsilon_t^{mp} \tag{10}$$

first proposed by Sims (1986) and used, as well, by Leeper and Roush (2003), associating a monetary policy shock with simultaneous movements in the interest rate and nominal money supply, presumably of opposite signs (although we do not impose this sign restriction), so that a monetary policy tightening results in an immediate rise in the federal funds rate and an immediate fall in Divisia M1. Belongia and Ireland (2015) expand this policy rule to include prices and output, so that it becomes the kind of generalized Taylor (1993) rule studied within a New Keynesian framework by Ireland (2001),

$$a_{41}P_t + a_{42}Y_t + R_t + a_{45}M_t = \sigma_{44}\varepsilon_t^{mp}.$$

In this form, the rule instructs the central bank to adjust the federal funds rate in response to changes in the money supply in addition to the aggregate price level and output. Belongia and

Ireland find, however, that whereas excluding the money supply from this rule by imposing the constraint $a_{45} = 0$ results in a statistically significant deterioration in the model's overall fit, excluding the price level and output by imposing $a_{41} = a_{42} = 0$ so as to obtain the restricted specification in equation (10) does virtually nothing to affect the model's empirical performance. Hence, the more parsimonious specification, linking the interest rate and money alone, serves as our preferred specification here as well. Note, however, that both equations (2) and (4) allow, quite flexibly, for a lagged response of the federal funds rate to changes in prices and output that is fully consistent with the spirit of the original Taylor (1993) rule.

Row five in equation (9) represents a more tightly-parameterized and theoretically-motivated money demand relation

$$a_{52}Y_t + (M_t - P_t) + a_{56}U_t = \sigma_{55}\varepsilon_t^{md}, \tag{11}$$

which links the real value of the Divisia M1 quantity index to output as the scale variable and the Divisia M1 user cost index as the associated price. Belongia (2006) argues strongly in support of this specification for money demand by noting that the user cost variable, as the price dual to the Divisia quantity aggregate, measures the "price" of monetary services in a theoretically coherent way, whereas the interest rate variables that are more typically included in statistical money demand equations reflect, instead, the price of bonds as money substitutes. Bringing the logic of traditional, simultaneous equations systems to bear in interpreting equations (10) and (11), our model distinguishes between shocks to money supply and shocks to money demand. This is done, first, by invoking the quantity-theoretic proposition that "money supply" refers to nominal money whereas "money demand" pertains to real money balances. Second, following Belongia, the interest rate is included in the money supply rule but not the money demand equation and the user cost of money is included in the money demand equation but not the money supply rule.

Finally, row six of equation (9) provides the equation

$$a_{64}R_t + a_{65}(M_t - P_t) + U_t = \sigma_{66}\varepsilon_t^{ms}, \tag{12}$$

which describes the behavior of the private financial institutions that, together with the Federal Reserve, create the liquid assets included in the Divisia M1 quantity aggregate. Belongia and Ireland (2014) and Ireland (2014) incorporate this "monetary system" in dynamic, stochastic, general equilibrium models to show how an increase in the federal funds rate gets passed along to consumers of monetary services in the form of a higher user cost; equation (12) allows the quantity of real monetary services created to affect the user cost as well, as it would if banks' costs rise as they expand their scale of operation.

Hamilton (1994, Ch.11) and Lutkepohl (2006, Ch.9) outline methods for estimating structural VARs like ours via maximum likelihood. In particular, even with the restrictions imposed on A in equation (9), fully efficient estimates of the reduced-form constant and slope coefficients in equation (4) can still be obtained by applying ordinary least squares, one equation at a time; then, the parameters of A and Σ can be estimated by maximizing the concentrated log-likelihood function. Since equation (9) imposes 19 restrictions on the off-diagonal elements of A, the model is over-identified and this approach must be used. For the just-identified triangular model, the parameters of A and Σ can be estimated in exactly the same way, although numerically identical estimates also can be obtained through the more usual approach of using the Cholesky decomposition of $\hat{\Omega}$ to help find the unique factorization shown in equation (6).

5. VAR RESULTS

5.1 Early Subsample: 1967 – 1983

Table 5 reports maximum likelihood estimates of key coefficients from the matrices A and Σ, obtained using data from the early subsample running from 1967:1 through 1983:4. To make the table easier to read, only the estimated equations with direct economic interpretations are shown: The monetary policy rule and money demand relation in equations (7) and (8) from the triangular model and the "interest rate-money" policy, money demand curve, and the monetary system relation from our preferred specification from equations (9)-(12). The top two panels display results when the aggregate price level, output, the Divisia money index, and the commodity price measure enter the VAR in log levels; the bottom two panels show what happens when those same variables are re-expressed as growth rates. As noted above, the federal funds rate and the user cost of money always enter the VAR as decimals. The standard errors, shown in parentheses below each estimated parameter, are computed using the formulas from Proposition 9.5 in Lutkepohl (2006, Ch.9, p.373).

In panel A, all variables can be seen to enter the equations of the triangular model with the expected sign. The monetary policy rule depicts the Federal Reserve as increasing the federal funds rate whenever the price level, output, or commodity prices rise, and money demand depends positively on prices and output as scale variables and inversely on the nominal interest rate as an opportunity cost measure. Much the same is true, however, in panel B, showing results from the non-triangular model in equation (9). In particular, the interest rate-money rule implies that the interest rate rises and the money stock falls on impact following a monetary policy shock. The demand for real money balances depends positively on output and negatively on the user cost of money, and the monetary system translates an increase in the federal funds rate into an increase in the user cost of money. Only the negative sign of the coefficient on real balances in the monetary system equation is inconsistent with the theory, since it implies that the user cost of money falls when the private financial system produces additional monetary services; this estimated coefficient, however, is quantitatively small and statistically insignificant. Panels C and D reveal, at least for this first subsample, that coefficients found when the VARs are re-estimated with data in growth rates resemble quite closely those obtained when the variables enter in log levels.

Figure 4 displays the impulse responses of the interest rate, money, GDP, and the GDP deflator to the identified monetary policy shock implied by each specification: with the triangular identification scheme or with the interest rate-money rule, and when the data are expressed in log levels or growth rates. To make the graphs fully comparable across all four cases, the vertical axis scales are held fixed moving from one column to the next, and the effects shown for each case are those that follow from the same one-standard deviation, positive innovation $\varepsilon_t^{mp} = 1$. Thus, to the extent that the different specifications imply different estimates of the volatility parameter σ_{44} entering into equations (7) and (10), the impact response on the variables included in the monetary policy rule will be larger or smaller. In addition, again to make the graphs fully comparable across specifications, the impulse responses for money growth, output growth, and inflation generated from the models estimated with data in logarithmic first differences are cumulated, so that the responses shown, even in the figure's last two columns, are for money, output, and prices in log levels. Finally, in each panel, the solid line traces out the impulse response itself, while the dashed lines provide plus-and-minus one standard error bands, computed as suggested by Hamilton (1994, Ch.11, pp.336-337); this method treats each impulse response as a vector-valued function of the estimated structural parameters and uses the numerical derivatives of that function to translate the standard errors for the structural parameters into standard errors for the impulse responses.

Looking across the first two rows, the graphs show that all four specifications associate a one-standard deviation monetary policy shock in this early subsample with an initial increase in the federal funds rate of about 100 basis points that decays over a two-year period. The Divisia monetary aggregate shows a much more persistent, 0.5 percent decline – the manifestation of tight policy emphasized by Friedman and Schwartz (1963a, 1963b) in their classic work but completely ignored in more recent empirical work that uses the funds rate, alone, as a sufficient statistic for the stance of Federal Reserve policy. Both model variants estimated with data in log levels associate this contractionary monetary policy shock with a persistent, but ultimately transitory, decline in output followed with a considerable lag by a decline in prices that mirrors, in both its size and persistence, the more rapid decline in money. Thus, these impulse responses trace out the set of effects traditionally associated with monetary policy shocks in accounts dating back to Hume (1777): A persistent, unanticipated decrease in the money supply leads to a transitory rise in the interest rate, a transitory fall in output, and a persistent decline in prices. The models estimated with data in growth rates, by contrast, imply that the same contractionary monetary policy shock is followed by a permanent decline in the level of output and a persistent *rise* in the level of prices. Thus, these impulse responses serve mainly to echo what was suggested before by the correlations from Tables 1-4: That the effects of monetary policy shocks on output and prices are captured more accurately by statistics computed with data in log levels than data in growth rates.

Finally, the panels of Table 6 decompose the forecast error variances in output and prices into components attributable to the structural disturbances with specific economic interpretations: The monetary policy and money demand shocks from equations (7) and (8) identified with the triangular specification and the monetary policy, money demand, and monetary system shocks from equations (10)-(12) identified when the non-triangular specification in equation (9) is used instead. As with the impulse responses, the forecasts from the model variants estimated with data in growth rates are cumulated, so as to show the forecast errors variance decompositions for the log levels of output and prices in those cases as well. Standard errors, shown in parentheses, are computed using a numerical procedure analogous to the one used to place standard error bands around the impulse responses in Figure 4. Table 6 confirms that both models estimated with data in log levels associate monetary policy shocks with sizable fractions – in excess of 30 percent – of the volatility in output, particularly at forecast horizons extending beyond two years, and even larger percentages – greater than 40 percent – of the volatility in prices at horizons of four years or more. Thus, especially when the VARs are estimated with data in log levels, both the impulse responses and variance decompositions support the widely-held view that Federal Reserve policy had the effect of generating cyclical instability in output and inflation from the middle 1960s through the late 1970s.

5.2 Middle Subsample: 1984 – 1999

Tables 7 and 8 and Figure 5 report exactly the same information in the same format as Tables 5 and 6 and Figure 4 when the VARs are estimated with data from the middle subsample covering the Great Moderation. Because the specifications estimated with data in growth rates exhibit the same shortcomings for this middle subsample and the most recent subsample as they do for the early subsample described above, our discussion in what follows focuses on the results from models estimated with data in log levels; for the sake of completeness, however, the tables and figures present all of the results from all model variants.

For this middle subsample, important differences appear across the model estimated with the triangular identification scheme and the model estimated with the interest rate-money rule for monetary policy. Panel A of Table 7 shows that the estimated coefficients of the Taylor-type rule in equation (7) all have the expected sign, suggesting that the Federal Reserve increases its target for the federal funds rate in response to a rise in aggregate prices, output, or commodity prices. Most noteworthy, however, is that the coefficient on prices in the money demand relation in equation (8) is negative and large in absolute value (though not quite statistically significant). Since the implied relation, associating rising prices with a decline as opposed to an increase in the money stock, would seem to provide a better description of money supply than money demand, this result points to a potentially serious shortcoming of the triangular model: It suggests that the *a priori* exclusion of a measure of money from the policy rule in equation (7) forces the triangular model to attribute the volatility in the data to money demand shocks, when they are more likely to be driven by monetary policy instead. By contrast, all of the coefficients shown in panel B are estimated to have the expected signs for our preferred specification in equation (9) that allows for simultaneity between interest rates and money in its description of monetary policy.

The impulse responses from Figure 5 provide further support for the idea that it is necessary to include money in the monetary policy rule to fully capture the effects that monetary policy has in the economy. Those in the second column, for the model with the interest rate-money rule, show much larger and more persistent declines in both money and output after a monetary policy shock than those in the first column, for the model with the triangular identification scheme. Likewise, panel A of Table 8 indicates that monetary policy shocks identified with the triangular model explain very little of the observed volatility in aggregate output and prices. However, the money demand shocks identified by the same model appear surprisingly important, accounting for more than 15 percent of the forecast error variance in output and 12 percent of the forecast error variance in prices at horizons four to five years out. These results, as in the previous case, are suggestive of problems distinguishing between money supply and money demand. Meanwhile, our preferred identification scheme, which includes money in the policy rule in equation (10) while also providing a more parsimonious and theoretically-motivated description of money demand, attributes much more of the volatility in output and prices to monetary policy shocks and much less to money demand disturbances. Focusing more narrowly on a sample period from 1982 through 1992, Gordon and Leeper (1994) also find that monetary policy shocks account for a sizeable fraction of the forecast error variance in output and prices at three-year horizons using a structural VAR that distinguishes explicitly between money supply and money demand. Our results corroborate and extend theirs, and cast some doubt on the popular view that Federal Reserve policy was no longer a source of instability in the American economy during the Great Moderation.

The one empirical shortcoming of our preferred model, when estimated using data from the middle subsample, is the persistent rise in the aggregate price level following a contractionary monetary policy shock that appears in the impulse response in the bottom row of the second column of Figure 5. This counterintuitive response could be another manifestation of the "price puzzle" that is often observed in VAR results, including our own, for the early subsample, shown previously in Figure 4. On the other hand, it is interesting to note that for this middle subsample, the decline in the money supply that follows a monetary policy shock eventually reverses itself; in fact, money remains above its initial level well beyond the 20-quarter horizon shown, suggesting a more traditional, quantity-theoretic explanation according to which the increase in prices represents, not a puzzle, but instead the natural outcome generated by a shock that eventually leads to an increase in the money supply. In other recent work, Giordani (2004) shows that evidence of the price puzzle disappears after a measure of the output gap replaces output itself in a three-variable VAR that also includes a measure of the aggregate price level and the federal funds rate. In the same spirit, Castelnuovo and Surico (2010) attribute the price puzzle to an omitted variable problem of a different sort, involving the failure of conventionally-specified VARs to account for persistent movements in expected inflation. Our own results complement these previous ones, by suggesting that the inclusion of a money supply variable in the VAR's information set can also help resolve puzzles associated with the response of aggregate prices to identified monetary policy shocks.

5.3 Recent Subsample: 2000 – 2013

Tables 9 and 10 and Figure 6 present the VAR results when the models are estimated with data from the most recent subsample, covering the period leading up to and during the financial crisis and the Great Recession. The coefficient estimates in panel A of Table 9 point to problems with the triangular identification scheme similar to those that emerge from data in the middle subsample. This time, it is the coefficient on output in the money demand relation in equation (8) that turns out to be negative; but, again, this inverse relation, with money contracting when output rises, seems to describe a money supply rule better than a money demand curve. And panel A of Table 10 shows sizable fractions of output and volatility attributed by the triangular model to money demand shocks – again, a puzzling finding that suggests that this specification fails to distinguish adequately between money supply and money demand.

Our preferred model, with the interest rate-money policy rule in equation (10), once again delivers more satisfactory results. All of the coefficient estimates in panel B of Table 9 have the expected sign. The impulse responses in the second column of Figure 6 associate an identified monetary policy shock with an increase in the interest rate and an immediate, sharp decline in the money supply that is followed, with a lag, by a decline in output and then, with a longer lag, by a fall in prices as well. Consistent with the raw correlations shown in Tables 2-4, in fact, the impulse responses from Figures 4-6 show a noticeable lengthening of the lag with which monetary policy actions affect output and prices moving from the earliest subsample to the more recent.

In contrast to the results that follow from the triangular identification scheme, those generated by our preferred structural VAR attribute, in panel B of Table 10, between 20 and 40 percent of the forecast error variance in output at horizons longer than three years to monetary policy shocks, and more than 30 percent of the forecast error variance in both output and prices at the five-year horizon to monetary policy disturbances. Looking across Tables 6, 8, and 10, in fact, our results consistently interpret monetary policy as an important source of volatility in output and, except for the period of the Great Moderation, an equally if not more important source of intermediate-term fluctuations in aggregate prices.

6. MONEY AND THE BUSINESS CYCLE: FACTS TO BE EXPLAINED

The empirical results presented here raise significant challenges for future research. As noted at the outset, neither purely real business models nor standard New Keynesian models are immediately equipped to address any of these facts, since measures of the money supply are largely, if not entirely, ignored by these popular analytic frameworks. Sustek (2010) extends a real business cycle model to demonstrate that the activities of a private banking system in an economy with multi-stage production can produce a slight, one or two-quarter lead of money over output even in the absence of New Keynesian nominal rigidities. Ireland (2003), however, compares the quantitative implications of dynamic, stochastic, general equilibrium models with and without price rigidities, and his results suggest that some form of monetary nonneutrality, which draws causal links between movements in money and subsequent movements in output, will be needed to account for the longer lags evident in the data summarized in Tables 3-5 and Figures 4-6. On the other hand, results from Ireland (2004) indicate that the most direct extensions to the New Keynesian framework, aimed at introducing measures of money into its IS and Phillips curve equations, help little in improving the model's econometric fit. New theoretical models that successfully depict a wider range of channels through which monetary policy affects the economy seem most desperately needed.[15]

Accounting for the noticeable changes in lag structures across the three sample periods, 1967-1983, 1984-1999, and 2000-2013, considered in both our reduced-form and structural analyses here poses yet another major challenge for theoretical modeling. Intriguingly, Havranek and Rusnek's (2013) detailed "meta-analysis" of the empirical literature across countries provides evidence that the lag between monetary policy actions and their effects on prices lengthens considerably when financial systems are more developed. Lucas and Nicolini (2015), meanwhile, attribute shifts in empirical money demand relations for the U.S. to regulatory changes in the banking industry taking place during the early 1980s – around the same point at which we detect a lengthening lag between movements in money and subsequent movements in output and prices. Taken together, all of these empirical results suggest that additional research might be directed fruitfully to theoretical analysis of how the private banking system acts alongside the Federal Reserve to create liquid assets. Work along the same lines as Sustek (2010), Belongia and Ireland (2014), and Ireland (2014) may help in deepening our understanding of how monetary policy actions propagate through the economy.

In any case, meeting these challenges will likely prove crucial in any attempt to identify and understand the fundamental causes of the deep recession of 2008 and the slow recovery that has followed. Ireland (2011), Barnett (2012), Hetzel (2012), and Tatom (2014) all argue that overly restrictive monetary policy was at least partly to blame for the length and severity of the Great Recession; our statistical results, pointing to stronger links between money, output, and prices since 2000, are consistent with this view. Has the United States economy, after a period of relative tranquility, re-entered a phase of both monetary and real instability, as suggested by Taylor (2009)? Only time will tell, but it seems possible that monetary policymakers have once again gone off track by neglecting the behavior of the money supply. This possibility, suggested by the echoes of Friedman and Schwartz's (1963a) earlier findings in our own, should be enough to motivate renewed interest in understanding the relations between money and the business cycle.

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FOOTNOTES

1. Of course, Friedman and Schwartz (1963b) were not the first to perceive a link between monetary contraction and the Great Depression: Currie (1934) made the same case, essentially in real time. Nor did Friedman and Schwartz's (1963a) theory of money and business cycles develop in a total vacuum: Indeed, their paper begins by acknowledging an intellectual debt to Irving Fisher's (1923) earlier analysis, describing business cycles as "a dance of the dollar." See Bordo and Rockoff (2013) for a comprehensive discussion of Fisher's influence on Friedman's monetary economics.

2. It should be noted that early attempts to re-introduce nominal variables and monetary non-neutralities into the real business cycle framework, including those by Cho and Cooley (1995), Cooley and Hansen (1995), and King and Watson (1996), did describe monetary policy through its effects on money growth; these specifications, however, were largely supplanted by others that depict the central bank as managing a short-term interest rate according to some variant of the Taylor (1993) rule. Nelson (2008) represents a more recent effort to re-establish the role of money in determining the steady-state rate of inflation in the New Keynesian model, while Benati (2009) and Sargent and Surico (2011) characterize empirically the long-run relations between money growth and inflation in the U.S., U.K., and several other countries and clarify the circumstances under which the quantity-theoretic link emphasized by Nelson ought to become evident in the data.

3. Laidler (2015) presents an overview of “three revolutions” in macroeconomic thought, which are relevant to the theme of this paper.

4. In a previous version of this paper, available as Belongia and Ireland (2013), we also display results using alternative measures of Divisia money constructed by Anderson and Jones (2011). As explained by Barnett *et al*. (2013), the Anderson-Jones Divisia measures differ from theirs in the choice of the benchmark return that is compared to each monetary asset’s own rate of return in computing the user, or opportunity, cost of holding that liquid asset instead of the illiquid alternative. Barnett *et al*. argue that the choice of the benchmark rate matters little in the construction of the quantity aggregate. Choice of the benchmark rate is important, however, if one wants to consider more specifically the fluctuations in the user cost – or price dual – to the Divisia quantity aggregate as, for example, Belongia and Ireland (2006) do. Consistent with this argument, our earlier results using the Anderson-Jones quantity data are very similar to those that we obtain with Barnett’s series here.

5. Estrella and Mishkin (1997) is but one of many previous studies to have dismissed a role for money in either monetary policymaking or forecasting after finding only weak statistical links between income or inflation and simple-sum measures of the U.S. money supply. It is worth noting that Hendrickson’s (2014) replication study overturns the results in Estrella and Mishkin after replacing simple-sum with Divisia measures of money.

6. The “Barnett Critique” is the conjecture that the failure to find significant relations between the quantity of money and aggregates fluctuations may be due more to errors in the measurement

of money than instability in the underlying relationships themselves. This terminology was coined by Chrystal and MacDonald (1994).

7. Another illustration can be found in the upper panel of Figure 1, which shows slower growth for Divisia M1 during the early 1980s. This divergence from the growth rate of simple-sum M1 can explain why Friedman's (1983, 1985) warnings of renewed inflation were in error. The bottom panel of Figure 1 shows that the growth rate of Divisia M2 was slower than its simple-sum counterpart in advance of the recessions that occurred in the early 1980s, 1991-1992, and, most recently, 2007-2009.

8. In the previous version of this paper, Belongia and Ireland (2013), we use the Hodrick-Prescott (1997) filter, instead, to isolate the cyclical component of each series. Consistent with Baxter and King's (1999) own findings, we find that their band-pass filter and the Hodrick-Prescott filter produce very similar results.

9. As noted above, we follow Baxter and King (1999) by approximating the ideal band pass filter for business cycle frequencies with a two-sided, weighted average of twelve quarterly leads and lags. Thus, the series used to compute the correlations between business cycle components in this table run from 1970:1 through 2010:4, although these filtered series are constructed with data that span the entire period from 1967:1 through 2013:4.

10. Also similarly to us, Reynard (2007) finds that data in log levels are more informative than data in first differences in drawing links between money and prices in the U.S., the Euro Area, and Switzerland.

11. Friedman and Kuttner (1992), for example, report evidence to suggest that money's influence on aggregate activity fell to insignificance once the sample period was extended beyond the 1970s. This evidence, however, is overturned in the studies using Divisia series noted above; inference, again, was influenced importantly by measurement.

12. To the extent that the demand for reserves increased as banks scaled back on their risk-taking in the aftermath of the financial crisis, these flight-to-quality dynamics would have reinforced the effects of interest on reserves that are the focus of Ireland's (2014) model.

13. Note, in addition, that the data used to estimate the VAR, unlike those used to compute the correlations in Tables 1-4, are not passed through the band-pass filter.

14. Three other recent papers take different, but complementary, approaches to modeling, statistically, the links between Divisia money, output, and prices. Keating *et al*. (2014) experiment with various triangular identification schemes in VARs that include Divisia money. El-Shagri, Giesen, and Kelly (2012) identify monetary policy shocks in a VAR that includes a Divisia monetary aggregate by imposing sign restrictions on impulse response functions as suggested by Faust (1998) and Canova and De Nicolo (2002). Finally, Anderson, Chauvet, and Jones (2015) estimate a multivariate regime-switching model that allows for distinct permanent

and transitory components in each series. All three of these studies provide further evidence associating monetary with real instability.

15. Andres, Lopez-Salido, and Nelson (2004) present a model of imperfect asset substitutability that might serve as a starting point for future research along these lines.

Table 1. Correlations, Full Sample: 1967:1 - 2013:4

A. Correlation of BP filtered log real GDP with BP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.12	-0.14	-0.14	-0.11	-0.06	-0.01	0.05	0.11	0.15	0.19	0.21	0.22	0.21	0.19	0.14	0.08	0.01
Divisia M1	-0.22	-0.22	-0.19	-0.15	-0.10	-0.04	0.04	0.11	0.18	0.24	0.29	0.32	0.33	0.32	0.28	0.21	0.13
Simple-Sum M2	-0.15	-0.19	-0.22	-0.23	-0.22	-0.18	-0.12	-0.04	0.05	0.14	0.22	0.29	0.34	0.35	0.33	0.28	0.19
Divisia M2	-0.36	-0.35	-0.32	-0.27	-0.21	-0.13	-0.05	0.05	0.15	0.25	0.34	0.41	0.45	0.45	0.41	0.32	0.22
Simple-Sum MZM	-0.16	-0.15	-0.12	-0.06	0.01	0.08	0.16	0.22	0.26	0.29	0.31	0.32	0.31	0.28	0.22	0.12	-0.01
Divisia MZM	-0.28	-0.26	-0.22	-0.16	-0.09	-0.02	0.06	0.14	0.20	0.26	0.30	0.33	0.34	0.32	0.26	0.18	0.08

B. Correlation of BP filtered log GDP deflator with BP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	0.01	0.09	0.16	0.23	0.27	0.30	0.32	0.31	0.28	0.23	0.15	0.04	-0.06	-0.17	-0.25	-0.30	-0.32
Divisia M1	0.07	0.16	0.24	0.31	0.36	0.38	0.39	0.37	0.32	0.25	0.14	0.02	-0.10	-0.22	-0.32	-0.38	-0.42
Simple-Sum M2	0.34	0.42	0.47	0.49	0.49	0.45	0.40	0.31	0.19	0.04	-0.12	-0.28	-0.41	-0.49	-0.51	-0.48	-0.39
Divisia M2	0.51	0.60	0.65	0.68	0.66	0.62	0.54	0.42	0.28	0.10	-0.10	-0.29	-0.45	-0.58	-0.65	-0.66	-0.62
Simple-Sum MZM	0.26	0.27	0.27	0.24	0.21	0.15	0.08	-0.01	-0.11	-0.23	-0.35	-0.45	-0.53	-0.58	-0.58	-0.54	-0.45
Divisia MZM	0.44	0.49	0.52	0.52	0.49	0.44	0.36	0.26	0.12	-0.03	-0.19	-0.34	-0.46	-0.56	-0.61	-0.61	-0.56

C. Correlation of real GDP growth with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.02	0.00	0.00	0.01	0.01	0.05	0.01	0.04	0.04	0.04	0.07	-0.01	0.08	0.00	0.10	0.04	-0.06
Divisia M1	-0.04	-0.03	0.01	-0.01	0.01	0.07	0.00	0.06	0.05	0.09	0.15	0.05	0.17	0.09	0.17	0.14	0.05
Simple-Sum M2	-0.05	-0.08	-0.06	-0.07	-0.06	-0.05	-0.07	-0.04	0.00	0.05	0.09	0.06	0.11	0.12	0.21	0.19	0.05
Divisia M2	-0.16	-0.14	-0.12	-0.11	-0.09	-0.03	-0.10	-0.05	-0.03	0.07	0.15	0.08	0.18	0.11	0.24	0.27	0.06
Simple-Sum MZM	-0.06	-0.05	-0.03	-0.03	0.01	0.06	0.07	0.07	0.07	0.10	0.11	0.09	0.14	0.09	0.19	0.20	0.02
Divisia MZM	-0.13	-0.11	-0.09	-0.07	-0.04	0.03	-0.02	0.01	0.01	0.09	0.14	0.08	0.16	0.10	0.21	0.24	0.04

D. Correlation of GDP deflator inflation with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	0.12	0.15	0.17	0.17	0.20	0.21	0.21	0.19	0.17	0.15	0.15	0.11	0.07	0.04	0.00	-0.01	0.01
Divisia M1	0.02	0.07	0.09	0.10	0.12	0.13	0.13	0.12	0.08	0.05	0.05	-0.02	-0.06	-0.10	-0.14	-0.18	-0.15
Simple-Sum M2	0.44	0.48	0.48	0.48	0.50	0.49	0.49	0.47	0.42	0.37	0.35	0.29	0.26	0.23	0.22	0.21	0.24
Divisia M2	0.21	0.27	0.28	0.27	0.29	0.27	0.23	0.21	0.13	0.05	0.02	-0.05	-0.13	-0.18	-0.21	-0.21	-0.20
Simple-Sum MZM	-0.02	0.00	-0.01	-0.02	0.00	-0.02	-0.04	-0.04	-0.06	-0.13	-0.15	-0.17	-0.19	-0.21	-0.20	-0.20	-0.17
Divisia MZM	0.06	0.10	0.12	0.10	0.12	0.09	0.05	0.05	-0.01	-0.09	-0.12	-0.17	-0.24	-0.28	-0.30	-0.30	-0.29

Table 2. Correlations, Early Subsample: 1967:1 - 1983:4

A. Correlation of BP filtered log real GDP with BP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.21	-0.38	-0.52	-0.60	-0.65	-0.66	-0.64	-0.59	-0.50	-0.37	-0.19	0.01	0.24	0.48	0.67	0.75	0.72
Divisia M1	-0.27	-0.43	-0.55	-0.65	-0.72	-0.76	-0.76	-0.71	-0.58	-0.39	-0.16	0.08	0.33	0.56	0.72	0.80	0.78
Simple-Sum M2	-0.27	-0.36	-0.43	-0.47	-0.47	-0.42	-0.32	-0.18	-0.01	0.17	0.34	0.49	0.61	0.69	0.70	0.63	0.48
Divisia M2	-0.43	-0.48	-0.49	-0.48	-0.44	-0.38	-0.28	-0.15	0.01	0.20	0.40	0.58	0.73	0.82	0.84	0.78	0.65
Simple-Sum MZM	-0.35	-0.34	-0.29	-0.22	-0.13	-0.02	0.10	0.23	0.37	0.49	0.60	0.69	0.77	0.77	0.68	0.50	0.27
Divisia MZM	-0.48	-0.50	-0.48	-0.43	-0.37	-0.28	-0.18	-0.04	0.12	0.29	0.47	0.64	0.77	0.85	0.85	0.76	0.60

B. Correlation of BP filtered log GDP deflator with BP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.15	0.07	0.27	0.43	0.56	0.67	0.74	0.76	0.71	0.57	0.38	0.18	-0.03	-0.22	-0.38	-0.49	-0.57
Divisia M1	-0.08	0.15	0.35	0.53	0.67	0.79	0.87	0.88	0.81	0.67	0.48	0.27	0.05	-0.15	-0.34	-0.50	-0.62
Simple-Sum M2	0.38	0.52	0.61	0.66	0.66	0.63	0.56	0.45	0.30	0.11	-0.10	-0.30	-0.47	-0.58	-0.62	-0.60	-0.51
Divisia M2	0.53	0.66	0.75	0.80	0.80	0.76	0.68	0.54	0.36	0.15	-0.06	-0.27	-0.45	-0.59	-0.67	-0.70	-0.69
Simple-Sum MZM	0.56	0.63	0.64	0.60	0.51	0.40	0.26	0.09	-0.09	-0.28	-0.45	-0.60	-0.73	-0.78	-0.75	-0.64	-0.52
Divisia MZM	0.59	0.70	0.77	0.80	0.78	0.72	0.61	0.46	0.26	0.06	-0.15	-0.35	-0.51	-0.64	-0.71	-0.74	-0.71

C. Correlation of real GDP growth with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	0.04	-0.12	-0.18	-0.17	-0.12	-0.07	-0.21	-0.15	-0.25	-0.09	-0.03	-0.19	-0.01	-0.06	0.29	0.47	0.28
Divisia M1	0.03	-0.10	-0.17	-0.16	-0.09	-0.09	-0.27	-0.22	-0.32	-0.10	0.01	-0.14	0.08	0.02	0.30	0.51	0.29
Simple-Sum M2	-0.06	-0.22	-0.23	-0.23	-0.20	-0.22	-0.27	-0.13	-0.03	0.09	0.19	0.16	0.14	0.24	0.43	0.44	0.25
Divisia M2	-0.10	-0.19	-0.22	-0.16	-0.09	-0.08	-0.19	-0.12	-0.11	0.06	0.16	0.13	0.27	0.20	0.41	0.52	0.24
Simple-Sum MZM	-0.11	-0.16	-0.22	-0.08	-0.04	-0.02	-0.13	-0.04	0.01	0.17	0.21	0.15	0.27	0.17	0.35	0.37	0.11
Divisia MZM	-0.13	-0.19	-0.23	-0.12	-0.04	-0.03	-0.15	-0.10	-0.10	0.08	0.16	0.12	0.29	0.20	0.44	0.54	0.21

D. Correlation of GDP deflator inflation with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.23	-0.12	0.09	0.04	0.12	0.15	0.18	0.27	0.26	0.22	0.21	0.17	-0.01	-0.05	-0.14	-0.18	-0.15
Divisia M1	-0.20	-0.09	0.11	0.06	0.15	0.22	0.27	0.36	0.33	0.27	0.24	0.19	0.04	-0.04	-0.15	-0.21	-0.20
Simple-Sum M2	0.21	0.33	0.39	0.42	0.46	0.44	0.44	0.45	0.28	0.17	0.09	-0.07	-0.20	-0.29	-0.29	-0.30	-0.27
Divisia M2	0.28	0.40	0.48	0.42	0.47	0.44	0.40	0.43	0.32	0.15	0.07	-0.03	-0.21	-0.28	-0.30	-0.28	-0.31
Simple-Sum MZM	0.34	0.43	0.50	0.35	0.42	0.36	0.28	0.29	0.14	-0.03	-0.08	-0.13	-0.29	-0.35	-0.30	-0.30	-0.26
Divisia MZM	0.32	0.42	0.48	0.38	0.44	0.39	0.35	0.39	0.29	0.12	0.05	-0.03	-0.21	-0.32	-0.32	-0.31	-0.33

Table 3. Correlations, Middle Subsample: 1984:1 - 1999:4

A. Correlation of BP filtered log real GDP with BP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.26	-0.23	-0.19	-0.14	-0.07	0.00	0.08	0.15	0.20	0.23	0.22	0.20	0.15	0.09	0.03	-0.04	-0.12
Divisia M1	-0.31	-0.26	-0.20	-0.12	-0.02	0.08	0.20	0.31	0.40	0.45	0.45	0.43	0.38	0.31	0.23	0.13	0.03
Simple-Sum M2	-0.31	-0.18	-0.07	0.02	0.09	0.13	0.16	0.16	0.14	0.10	0.07	0.05	0.04	0.05	0.06	0.06	0.08
Divisia M2	-0.62	-0.49	-0.33	-0.17	0.00	0.15	0.28	0.37	0.41	0.40	0.34	0.26	0.17	0.08	-0.01	-0.10	-0.17
Simple-Sum MZM	-0.42	-0.34	-0.22	-0.08	0.07	0.22	0.35	0.44	0.47	0.45	0.40	0.33	0.26	0.18	0.10	0.00	-0.12
Divisia MZM	-0.50	-0.43	-0.31	-0.18	-0.03	0.12	0.26	0.37	0.42	0.42	0.38	0.31	0.24	0.15	0.06	-0.03	-0.14

B. Correlation of BP filtered log GDP deflator with BP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	0.04	0.16	0.25	0.33	0.39	0.42	0.42	0.39	0.33	0.23	0.09	-0.05	-0.19	-0.31	-0.42	-0.50	-0.53
Divisia M1	0.27	0.36	0.42	0.45	0.44	0.40	0.34	0.24	0.11	-0.04	-0.20	-0.35	-0.48	-0.59	-0.66	-0.71	-0.71
Simple-Sum M2	0.71	0.61	0.50	0.40	0.30	0.21	0.14	0.08	0.03	-0.01	-0.05	-0.07	-0.09	-0.10	-0.11	-0.10	-0.08
Divisia M2	0.70	0.76	0.79	0.77	0.73	0.65	0.54	0.41	0.25	0.07	-0.12	-0.29	-0.44	-0.56	-0.65	-0.69	-0.68
Simple-Sum MZM	0.52	0.54	0.51	0.46	0.38	0.28	0.18	0.09	-0.01	-0.12	-0.22	-0.32	-0.40	-0.47	-0.51	-0.52	-0.48
Divisia MZM	0.51	0.59	0.63	0.62	0.59	0.52	0.42	0.30	0.16	0.01	-0.15	-0.31	-0.44	-0.55	-0.63	-0.67	-0.66

C. Correlation of real GDP growth with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.35	-0.24	-0.14	-0.21	-0.21	-0.12	-0.14	-0.02	-0.01	0.01	-0.01	-0.08	-0.01	-0.10	-0.05	-0.13	-0.03
Divisia M1	-0.17	-0.03	0.08	-0.01	-0.02	0.11	0.05	0.22	0.24	0.25	0.24	0.11	0.18	0.08	0.14	0.03	0.09
Simple-Sum M2	-0.30	-0.18	-0.10	-0.06	-0.07	-0.02	-0.04	0.04	0.07	0.07	0.07	0.01	0.11	0.16	0.19	0.16	0.24
Divisia M2	-0.33	-0.18	-0.07	-0.08	-0.06	0.07	0.05	0.20	0.23	0.27	0.25	0.08	0.14	0.11	0.17	0.08	0.14
Simple-Sum MZM	-0.26	-0.20	-0.14	-0.06	0.02	0.15	0.17	0.26	0.26	0.28	0.21	0.06	0.09	0.14	0.18	0.10	0.07
Divisia MZM	-0.25	-0.16	-0.09	-0.09	-0.03	0.10	0.11	0.24	0.26	0.29	0.25	0.08	0.11	0.11	0.16	0.08	0.09

D. Correlation of GDP deflator inflation with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	0.30	0.35	0.42	0.46	0.44	0.47	0.45	0.48	0.46	0.40	0.38	0.28	0.19	0.20	0.15	0.12	0.12
Divisia M1	0.09	0.15	0.17	0.19	0.16	0.16	0.09	0.12	0.03	-0.04	-0.08	-0.19	-0.26	-0.24	-0.30	-0.31	-0.30
Simple-Sum M2	0.68	0.67	0.70	0.61	0.56	0.50	0.36	0.39	0.31	0.22	0.16	0.07	0.06	0.06	0.03	0.03	-0.02
Divisia M2	0.41	0.46	0.51	0.48	0.45	0.43	0.30	0.31	0.23	0.12	0.05	-0.08	-0.18	-0.17	-0.24	-0.25	-0.29
Simple-Sum MZM	0.37	0.43	0.49	0.40	0.36	0.32	0.18	0.19	0.14	0.03	-0.04	-0.16	-0.23	-0.24	-0.29	-0.27	-0.31
Divisia MZM	0.24	0.30	0.36	0.33	0.31	0.30	0.18	0.18	0.12	0.03	-0.03	-0.14	-0.24	-0.25	-0.31	-0.31	-0.36

Table 4. Correlations, Recent Subsample: 2000:1 - 2013:4

A. Correlation of BP filtered log real GDP with BP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.18	0.01	0.21	0.39	0.54	0.65	0.73	0.80	0.83	0.82	0.76	0.64	0.48	0.27	0.03	-0.18	-0.33
Divisia M1	-0.23	-0.03	0.16	0.33	0.48	0.61	0.71	0.79	0.84	0.84	0.78	0.68	0.52	0.32	0.10	-0.09	-0.23
Simple-Sum M2	0.69	0.73	0.76	0.75	0.72	0.65	0.54	0.40	0.22	0.04	-0.11	-0.25	-0.42	-0.58	-0.68	-0.69	-0.60
Divisia M2	0.38	0.48	0.56	0.64	0.70	0.73	0.73	0.69	0.60	0.47	0.31	0.15	-0.04	-0.26	-0.46	-0.59	-0.62
Simple-Sum MZM	0.73	0.75	0.75	0.73	0.69	0.62	0.50	0.33	0.12	-0.12	-0.35	-0.55	-0.70	-0.79	-0.81	-0.77	-0.67
Divisia MZM	0.56	0.62	0.67	0.70	0.72	0.72	0.68	0.58	0.42	0.21	0.00	-0.20	-0.39	-0.56	-0.67	-0.72	-0.69

B. Correlation of HP filtered log GDP deflator with HP filtered log nominal money lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	0.45	0.63	0.77	0.84	0.86	0.83	0.78	0.72	0.64	0.51	0.32	0.09	-0.15	-0.37	-0.52	-0.58	-0.56
Divisia M1	0.40	0.58	0.72	0.83	0.88	0.88	0.84	0.79	0.71	0.58	0.40	0.18	-0.05	-0.27	-0.42	-0.49	-0.49
Simple-Sum M2	0.88	0.82	0.72	0.58	0.42	0.25	0.08	-0.10	-0.28	-0.44	-0.59	-0.74	-0.86	-0.87	-0.74	-0.50	-0.22
Divisia M2	0.84	0.88	0.88	0.83	0.75	0.64	0.50	0.35	0.18	-0.02	-0.24	-0.45	-0.64	-0.77	-0.76	-0.64	-0.44
Simple-Sum MZM	0.83	0.74	0.64	0.51	0.34	0.14	-0.09	-0.32	-0.53	-0.69	-0.81	-0.88	-0.90	-0.86	-0.74	-0.54	-0.30
Divisia MZM	0.87	0.85	0.81	0.73	0.62	0.46	0.28	0.07	-0.15	-0.36	-0.54	-0.69	-0.81	-0.85	-0.79	-0.63	-0.40

C. Correlation of real GDP growth with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	-0.03	0.02	0.04	0.09	0.20	0.21	0.27	0.18	0.29	0.20	0.21	0.14	0.29	0.16	0.12	-0.16	-0.35
Divisia M1	-0.02	-0.01	0.06	0.13	0.25	0.29	0.31	0.27	0.36	0.29	0.25	0.19	0.34	0.23	0.16	-0.12	-0.22
Simple-Sum M2	0.18	0.14	0.18	0.22	0.22	0.23	0.23	0.04	0.04	0.08	0.02	-0.07	0.06	-0.06	-0.04	-0.11	-0.39
Divisia M2	0.13	0.11	0.18	0.22	0.28	0.31	0.35	0.20	0.19	0.20	0.15	0.05	0.17	0.06	0.03	-0.12	-0.38
Simple-Sum MZM	0.38	0.30	0.24	0.23	0.28	0.31	0.35	0.19	0.10	0.03	-0.12	-0.26	-0.30	-0.25	-0.27	-0.22	-0.35
Divisia MZM	0.25	0.18	0.19	0.22	0.29	0.34	0.37	0.24	0.16	0.14	0.05	-0.02	-0.05	-0.06	-0.13	-0.19	-0.36

D. Correlation of GDP deflator inflation with nominal money growth lagged by k quarters

k	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Simple-Sum M1	0.00	0.07	0.09	0.04	0.10	0.23	0.18	0.05	0.04	-0.06	0.04	-0.11	-0.16	-0.36	-0.50	-0.51	-0.39
Divisia M1	0.12	0.22	0.27	0.21	0.31	0.40	0.38	0.22	0.17	0.07	0.17	-0.03	-0.03	-0.27	-0.37	-0.49	-0.26
Simple-Sum M2	0.27	0.35	0.25	0.14	0.19	0.20	0.14	0.05	-0.11	-0.18	-0.06	-0.19	-0.16	-0.31	-0.40	-0.38	-0.02
Divisia M2	0.32	0.43	0.36	0.26	0.35	0.36	0.30	0.18	0.01	-0.08	0.04	-0.12	-0.15	-0.32	-0.47	-0.46	-0.14
Simple-Sum MZM	0.35	0.39	0.36	0.27	0.33	0.17	0.07	0.00	-0.22	-0.32	-0.31	-0.37	-0.36	-0.30	-0.40	-0.34	-0.09
Divisia MZM	0.35	0.41	0.41	0.31	0.42	0.30	0.22	0.16	-0.05	-0.15	-0.10	-0.23	-0.28	-0.30	-0.47	-0.44	-0.15

Table 5. Maximum Likelihood Estimates from Structural VARs, Early Subsample: 1967:1 - 1983:4

A. Triangular identification: Data in log levels

Monetary policy	$R = 0.57P + 0.19Y + 0.11CP$	$\sigma = 0.0107$
	(0.50) (0.19) (0.04)	(0.0009)
Money demand	$M = 0.55P + 0.14Y - 0.02R + 0.03CP$	$\sigma = 0.0044$
	(0.21) (0.08) (0.05) (0.02)	(0.0004)

B. Interest rate-money rule: Data in log levels

Monetary policy	$R = 1.95M$	$\sigma = 0.0142$
	(0.74)	(0.0024)
Money demand	$M - P = 0.25Y - 0.23U$	$\sigma = 0.0057$
	(0.11) (0.09)	(0.0010)
Monetary system	$U = 1.37R - 0.07(M-P)$	$\sigma = 0.0052$
	(0.06) (0.14)	(0.0005)

C. Triangular identification: Data in growth rates

Monetary policy	$R = 0.34P + 0.10Y + 0.10CP$	$\sigma = 0.0108$
	(0.44) (0.18) (0.03)	(0.0009)
Money demand	$M = 0.40P + 0.21Y + 0.02R + 0.03CP$	$\sigma = 0.0048$
	(0.20) (0.08) (0.05) (0.01)	(0.0004)

D. Interest rate-money rule: Data in growth rates

Monetary policy	$R = 1.63M$	$\sigma = 0.0133$
	(0.58)	(0.0020)
Money demand	$M - P = 0.28Y - 0.22U$	$\sigma = 0.0063$
	(0.11) (0.10)	(0.0011)
Monetary system	$U = 1.35R - 0.15(M-P)$	$\sigma = 0.0051$
	(0.06) (0.12)	(0.0005)

Notes: σ measures the standard deviation of the structural disturbance associated with each equation. Standard errors are in parentheses.

Table 6. Forecast Error Variance Decompositions from Structural VARs, Early Subsample: 1967:1 - 1983:4

A. Triangular identification: Data in log levels

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	GDP deflator: Monetary policy	GDP deflator: Money demand
2	0.0	0.8	1.6	0.6
	(0.1)	(1.6)	(1.9)	(1.2)
4	23.1	0.7	3.2	1.6
	(8.6)	(1.3)	(3.5)	(2.4)
8	45.0	0.3	2.1	3.3
	(11.4)	(0.5)	(1.6)	(4.8)
12	42.6	0.6	18.4	5.2
	(13.4)	(1.3)	(13.8)	(7.5)
16	40.3	2.1	44.3	6.1
	(13.7)	(3.7)	(16.0)	(7.4)
20	39.1	4.1	50.5	7.3
	(13.5)	(5.3)	(14.6)	(7.7)

B. Interest rate-money rule: Data in log levels

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	Real GDP: Monetary system	GDP deflator: Monetary policy	GDP deflator: Money demand	GDP deflator: Monetary system
2	0.2	0.6	4.6	0.4	3.0	0.0
	(0.9)	(1.5)	(4.2)	(1.0)	(2.7)	(0.0)
4	16.8	11.4	3.5	0.9	9.3	0.5
	(8.4)	(7.6)	(3.5)	(2.1)	(6.3)	(1.7)
8	31.7	23.8	8.1	1.2	9.7	5.5
	(14.5)	(13.6)	(8.4)	(1.3)	(8.5)	(8.6)
12	31.0	19.6	11.0	17.6	7.3	5.6
	(15.0)	(13.2)	(12.6)	(13.7)	(5.2)	(9.5)
16	30.6	18.5	10.6	43.2	9.8	4.2
	(14.7)	(12.1)	(12.8)	(16.6)	(8.3)	(6.0)
20	30.4	19.2	10.8	52.3	9.1	4.7
	(14.7)	(11.8)	(12.5)	(15.4)	(9.9)	(7.5)

C. Triangular identification: Data in growth rates

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	GDP deflator: Monetary policy	GDP deflator: Money demand
2	0.1	4.7	0.9	0.1
	(0.6)	(3.5)	(1.4)	(0.3)
4	11.9	11.6	1.2	0.3
	(7.8)	(6.7)	(2.3)	(1.2)
8	20.7	7.6	0.9	0.4
	(12.5)	(6.3)	(2.6)	(1.9)
12	21.2	4.6	0.5	0.4
	(14.2)	(5.1)	(1.7)	(2.3)
16	21.7	3.3	0.4	0.4
	(15.7)	(4.2)	(0.9)	(2.8)
20	22.5	2.5	0.3	0.5
	(16.7)	(3.5)	(0.6)	(3.4)

D. Interest rate-money rule: Data in growth rates

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	Real GDP: Monetary system	GDP deflator: Monetary policy	GDP deflator: Money demand	GDP deflator: Monetary system
2	2.6	3.3	4.2	1.1	0.7	0.0
	(3.3)	(3.4)	(3.9)	(1.5)	(1.2)	(0.0)
4	26.2	2.1	2.9	2.3	1.5	0.1
	(12.0)	(1.5)	(3.3)	(3.6)	(2.4)	(0.9)
8	31.7	6.9	3.9	2.4	2.6	1.3
	(15.0)	(8.3)	(5.4)	(4.8)	(4.7)	(4.0)
12	27.8	12.0	5.1	1.8	2.8	1.8
	(16.6)	(13.8)	(8.4)	(4.5)	(6.3)	(5.6)
16	25.7	15.4	5.6	1.5	2.6	1.9
	(17.5)	(17.8)	(9.8)	(4.2)	(7.2)	(6.1)
20	24.6	17.9	5.9	1.3	2.4	1.8
	(18.2)	(20.8)	(10.5)	(4.0)	(7.7)	(6.2)

Notes: Each entry indicates the percentage of the forcast error variance in real GDP or the GDP deflator due to the indicated shock, as implied by the indicated identification scheme and data transformation. Standard errors are in parentheses.

Table 7. Maximum Likelihood Estimates from Structural VARs, Middle Subsample: 1984:1 - 1999:4

A. Triangular identification: Data in log levels		
Monetary policy	R = 0.58P + 0.11Y + 0.03CP	σ = 0.0032
	(0.31) (0.11) (0.02)	(0.0003)
Money demand	M = -0.71P + 0.27Y - 0.28R - 0.02CP	σ = 0.0042
	(0.42) (0.14) (0.17) (0.02)	(0.0004)
B. Interest rate-money rule: Data in log levels		
Monetary policy	R = 2.99M	σ = 0.0154
	(5.03)	(0.0231)
Money demand	M - P = 0.80Y - 1.54U	σ = 0.0084
	(0.43) (0.75)	(0.0037)
Monetary system	U = 2.10R + 0.12(M-P)	σ = 0.0040
	(0.21) (0.17)	(0.0005)
C. Triangular identification: Data in growth rates		
Monetary policy	R = 0.81P + 0.18Y + 0.03CP	σ = 0.0033
	(0.31) (0.11) (0.02)	(0.0003)
Money demand	M = -0.41P + 0.16Y - 0.34R - 0.02CP	σ = 0.0044
	(0.43) (0.15) (0.17) (0.02)	(0.0004)
D. Interest rate-money rule: Data in growth rates		
Monetary policy	R = 4.54M	σ = 0.0233
	(9.56)	(0.0455)
Money demand	M - P = 0.92Y - 1.53U	σ = 0.0085
	(0.44) (0.66)	(0.0035)
Monetary system	U = 2.07R + 0.12(M-P)	σ = 0.0041
	(0.19) (0.17)	(0.0005)

Notes: σ measures the standard deviation of the structural disturbance associated with each equation. Standard errors are in parentheses.

Table 8. Forecast Error Variance Decompositions from Structural VARs, Middle Subsample: 1984:1 - 1999:4

A. Triangular identification: Data in log levels

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	GDP deflator: Monetary policy	GDP deflator: Money demand
2	1.3	0.2	1.3	2.6
	(1.9)	(0.7)	(1.7)	(2.4)
4	2.5	0.4	2.7	7.4
	(4.3)	(0.6)	(4.0)	(5.5)
8	3.2	5.6	3.7	11.3
	(6.5)	(6.4)	(7.0)	(8.5)
12	3.0	11.5	4.6	12.5
	(7.2)	(10.4)	(9.5)	(10.3)
16	2.8	15.3	5.5	12.8
	(7.7)	(13.0)	(11.4)	(11.6)
20	2.8	17.6	6.4	12.8
	(8.4)	(14.9)	(12.7)	(12.3)

B. Interest rate-money rule: Data in log levels

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	Real GDP: Monetary system	GDP deflator: Monetary policy	GDP deflator: Money demand	GDP deflator: Monetary system
2	0.1	2.8	0.1	2.1	0.7	2.8
	(0.5)	(2.9)	(0.4)	(2.8)	(1.5)	(3.1)
4	2.4	6.6	1.6	7.4	1.5	7.8
	(4.0)	(7.5)	(3.8)	(8.1)	(3.8)	(8.7)
8	15.9	8.1	6.3	11.9	2.6	10.5
	(12.8)	(12.2)	(8.5)	(13.2)	(7.4)	(13.3)
12	28.7	7.2	9.4	12.5	3.7	11.0
	(18.1)	(13.5)	(12.9)	(15.6)	(10.2)	(14.9)
16	36.6	6.2	10.9	12.1	4.7	11.1
	(21.1)	(13.8)	(14.8)	(16.7)	(11.9)	(15.3)
20	41.2	5.7	11.6	11.4	5.6	10.9
	(23.0)	(14.0)	(15.8)	(17.0)	(13.0)	(15.3)

C. Triangular identification: Data in growth rates

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	GDP deflator: Monetary policy	GDP deflator: Money demand
2	0.5	1.3	0.6	0.8
	(1.1)	(1.8)	(1.2)	(1.3)
4	0.4	2.3	0.2	2.1
	(1.7)	(3.6)	(0.6)	(3.2)
8	0.7	1.9	0.7	2.0
	(2.9)	(4.2)	(2.4)	(4.1)
12	1.2	1.4	1.5	1.5
	(4.3)	(4.0)	(4.4)	(4.0)
16	1.6	1.2	2.3	1.2
	(5.4)	(3.8)	(6.0)	(3.8)
20	2.0	1.0	3.2	1.1
	(6.2)	(3.6)	(7.3)	(3.8)

D. Interest rate-money rule: Data in growth rates

Quarters ahead	Real GDP: Monetary policy	Real GDP: Money demand	Real GDP: Monetary system	GDP deflator: Monetary policy	GDP deflator: Money demand	GDP deflator: Monetary system
2	0.6	1.5	0.0	0.3	0.9	0.1
	(1.3)	(2.1)	(0.2)	(0.9)	(1.4)	(0.6)
4	0.9	2.3	0.0	2.8	0.9	0.2
	(2.6)	(3.9)	(0.2)	(4.5)	(2.3)	(0.6)
8	0.5	3.0	0.1	5.2	0.3	1.9
	(1.8)	(6.1)	(0.6)	(9.0)	(1.3)	(4.2)
12	0.3	3.4	0.2	5.7	0.1	3.7
	(0.6)	(7.8)	(1.6)	(11.0)	(0.4)	(6.8)
16	0.3	3.6	0.5	6.2	0.2	5.0
	(1.3)	(8.8)	(2.6)	(12.5)	(0.7)	(8.9)
20	0.4	3.8	0.7	6.7	0.2	6.0
	(2.1)	(9.5)	(3.6)	(13.6)	(1.7)	(10.4)

Notes: Each entry indicates the percentage of the forcast error variance in real GDP or the GDP deflator due to the indicated shock, as implied by the indicated identification scheme and data transformation. Standard errors are in parentheses.

Table 9. Maximum Likelihood Estimates from Structural VARs, Recent Subsample: 2000:1 - 2013:4

A. Triangular identification: Data in log levels

Monetary policy	$R = 0.56P + 0.19Y + 0.00CP$	$\sigma = 0.0021$
	(0.22) (0.06) (0.01)	(0.0002)
Money demand	$M = 0.78P - 0.38Y - 0.25R + 0.00CP$	$\sigma = 0.0086$
	(0.97) (0.29) (0.57) (0.03)	(0.0008)

B. Interest rate-money rule: Data in log levels

Monetary policy	$R = 0.30M$	$\sigma = 0.0038$
	(0.61)	(0.0042)
Money demand	$M - P = 0.01Y - 2.37U$	$\sigma = 0.0182$
	(0.51) (3.69)	(0.0228)
Monetary system	$U = 3.77R + 0.57(M-P)$	$\sigma = 0.0088$
	(3.07) (0.21)	(0.0039)

C. Triangular identification: Data in growth rates

Monetary policy	$R = 0.41P + 0.20Y + 0.01CP$	$\sigma = 0.0020$
	(0.19) (0.06) (0.01)	(0.0002)
Money demand	$M = 0.10P - 0.41Y - 1.05R + 0.02CP$	$\sigma = 0.0082$
	(0.80) (0.29) (0.55) (0.03)	(0.0008)

D. Interest rate-money rule: Data in growth rates

Monetary policy	$R = -0.07M$	$\sigma = 0.0025$
	(0.06)	(0.0002)
Money demand	$M - P = -0.58Y - 0.35U$	$\sigma = 0.0086$
	(0.24) (0.47)	(0.0009)
Monetary system	$U = 1.19R + 0.20(M-P)$	$\sigma = 0.0074$
	(0.48) (0.35)	(0.0011)

Notes: σ measures the standard deviation of the structural disturbance associated with each equation. Standard errors are in parentheses.

Table 10. Forecast Error Variance Decompositions from Structural VARs, Recent Subsample: 2000:1 - 2013:4

A. Triangular identification: Data in log levels

	Real GDP		GDP deflator	
Quarters ahead	Monetary policy	Money demand	Monetary policy	Money demand
2	0.0	0.1	0.8	6.7
	(0.2)	(0.7)	(1.5)	(5.2)
4	0.2	0.2	0.4	5.4
	(1.1)	(0.3)	(0.8)	(4.7)
8	1.1	5.7	0.7	2.8
	(3.4)	(7.1)	(1.9)	(3.2)
12	5.6	18.4	3.0	4.6
	(7.4)	(15.1)	(5.7)	(5.0)
16	9.1	27.3	7.8	13.1
	(8.8)	(15.9)	(9.3)	(14.0)
20	8.7	27.7	11.7	23.5
	(8.5)	(14.2)	(10.5)	(18.4)

B. Interest rate-money rule: Data in log levels

	Real GDP			GDP deflator		
Quarters ahead	Monetary policy	Money demand	Monetary system	Monetary policy	Money demand	Monetary system
2	0.1	0.5	0.0	8.4	0.1	1.2
	(0.4)	(1.0)	(0.2)	(7.8)	(1.5)	(4.7)
4	0.4	0.3	0.4	6.2	0.4	1.3
	(1.3)	(0.5)	(1.1)	(7.7)	(2.2)	(3.8)
8	6.5	0.3	0.8	2.6	0.2	1.3
	(8.3)	(1.4)	(2.7)	(3.0)	(1.4)	(2.9)
12	21.8	0.3	2.4	7.0	0.3	0.9
	(16.2)	(1.1)	(10.0)	(7.3)	(1.7)	(2.0)
16	34.3	0.4	4.3	18.5	0.5	1.4
	(19.6)	(3.5)	(16.9)	(15.0)	(3.7)	(6.2)
20	35.8	0.4	5.3	30.4	0.6	2.9
	(21.0)	(3.9)	(19.3)	(19.3)	(5.5)	(12.7)

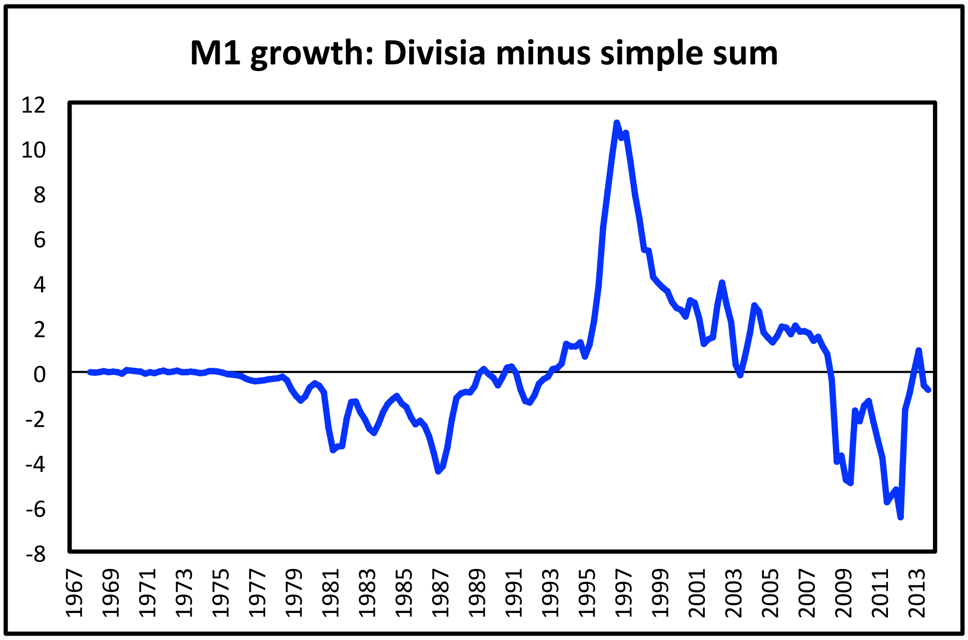
C. Triangular identification: Data in growth rates

	Real GDP		GDP deflator	
Quarters ahead	Monetary policy	Money demand	Monetary policy	Money demand
2	0.1	0.2	0.3	6.2
	(0.4)	(0.7)	(0.8)	(4.4)
4	0.1	0.1	0.9	8.2
	(0.3)	(0.2)	(2.1)	(6.4)
8	1.3	0.2	1.0	6.4
	(3.5)	(1.0)	(3.2)	(7.0)
12	3.7	0.7	0.6	5.6
	(6.9)	(2.5)	(2.6)	(7.3)
16	5.8	1.4	0.5	5.0
	(9.3)	(3.9)	(1.6)	(7.4)
20	7.1	2.0	0.5	4.6
	(10.6)	(4.8)	(1.0)	(7.4)

D. Interest rate-money rule: Data in growth rates

	Real GDP			GDP deflator		
Quarters ahead	Monetary policy	Money demand	Monetary system	Monetary policy	Money demand	Monetary system
2	0.6	1.1	2.4	0.0	6.5	0.8
	(1.5)	(2.1)	(2.9)	(0.4)	(5.4)	(2.3)
4	0.4	0.6	3.6	1.2	10.8	0.4
	(1.3)	(2.1)	(5.7)	(3.4)	(9.2)	(1.9)
8	0.8	0.3	10.5	1.5	9.9	0.2
	(2.3)	(1.6)	(16.0)	(5.2)	(11.2)	(1.0)
12	2.6	0.2	18.2	1.0	9.2	0.9
	(5.7)	(0.5)	(24.2)	(4.3)	(11.8)	(5.5)
16	4.3	0.3	24.7	0.7	8.5	2.2
	(8.2)	(1.7)	(29.4)	(2.9)	(11.9)	(10.5)
20	5.2	0.4	29.2	0.6	8.0	3.5
	(9.6)	(2.8)	(32.4)	(1.9)	(11.8)	(14.6)

Notes: Each entry indicates the percentage of the forcast error variance in real GDP or the GDP deflator due to the indicated shock, as implied by the indicated identification scheme and data transformation. Standard errors are in parentheses.



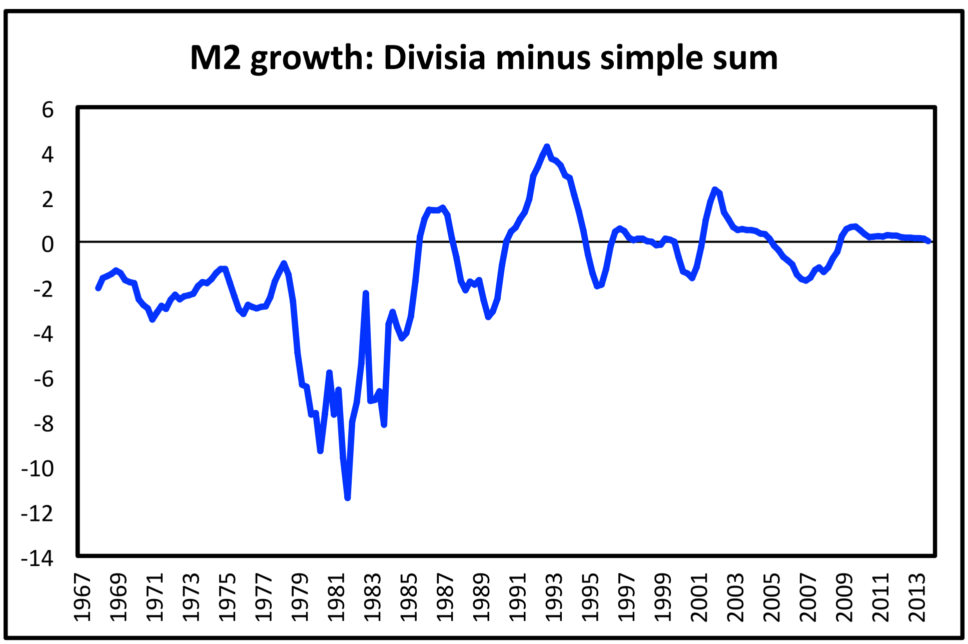


Figure 1. Differences in year-over-year growth rates of Divisia and simple-sum monetary aggregates, in percentage points.

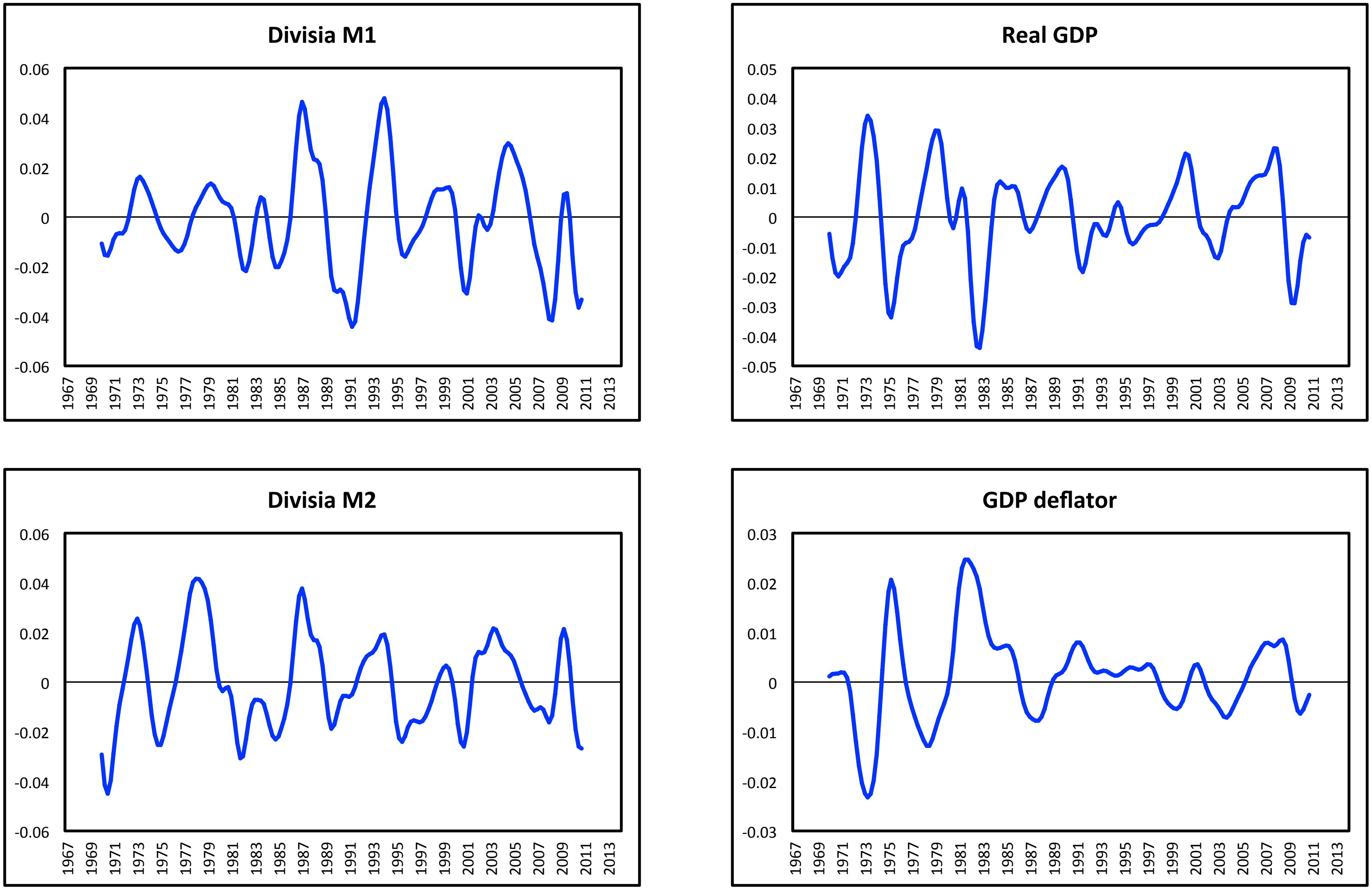
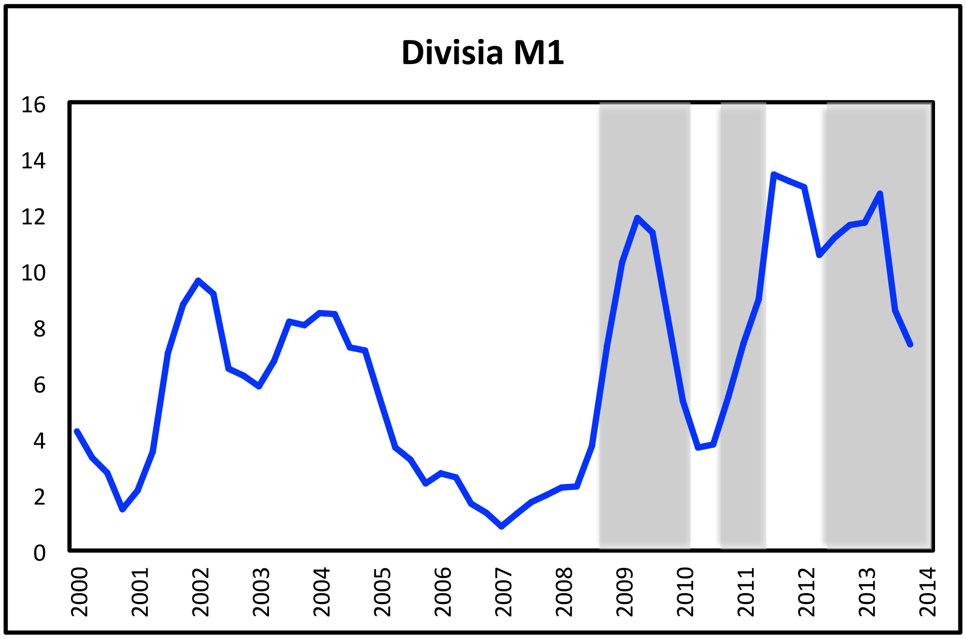


Figure 2. Cyclical components of Divisia money, output, and prices. Computed with Baxter and King's (1999) band pass filter. All variables in logs.



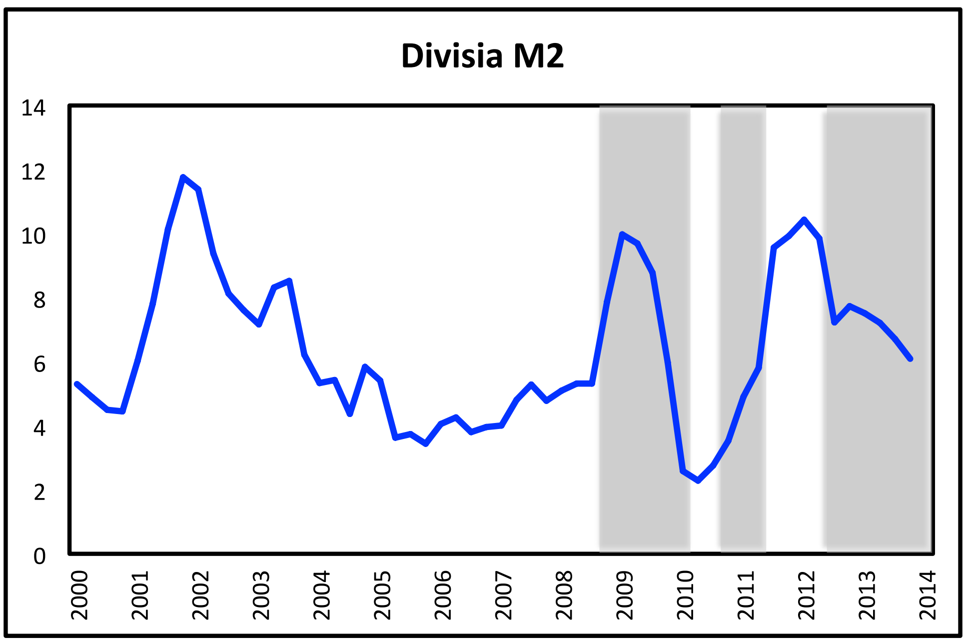


Figure 3. Year-over-year growth rates in Divisia money, in percentage points. Episodes of Large Scale Asset Purchases by the Federal Reserve are shaded.

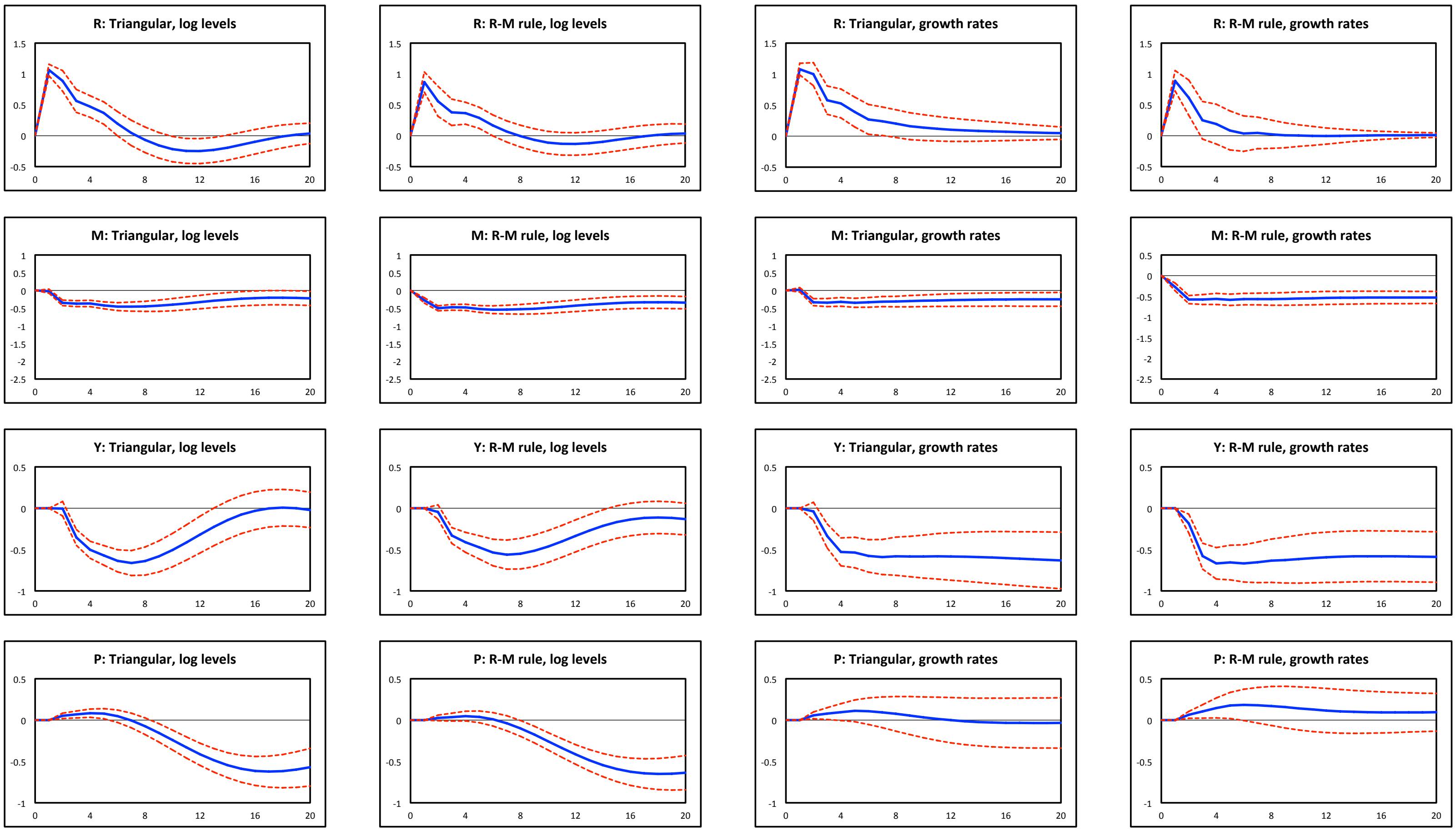


Figure 4. Impulse Responses, Early Subsample: 1967:1 - 1983:4. Each column shows the percentage-point response of the federal funds rate (R), Divisia M1 (M), real GDP (Y), and the GDP deflator (P) to a one-standard-deviation monetary policy shock, identified using either the triangular model or the model with an interest rate-money policy rule and estimated with data either in log levels or growth rates. Dashed lines provide plus-and-minus one standard error bands.

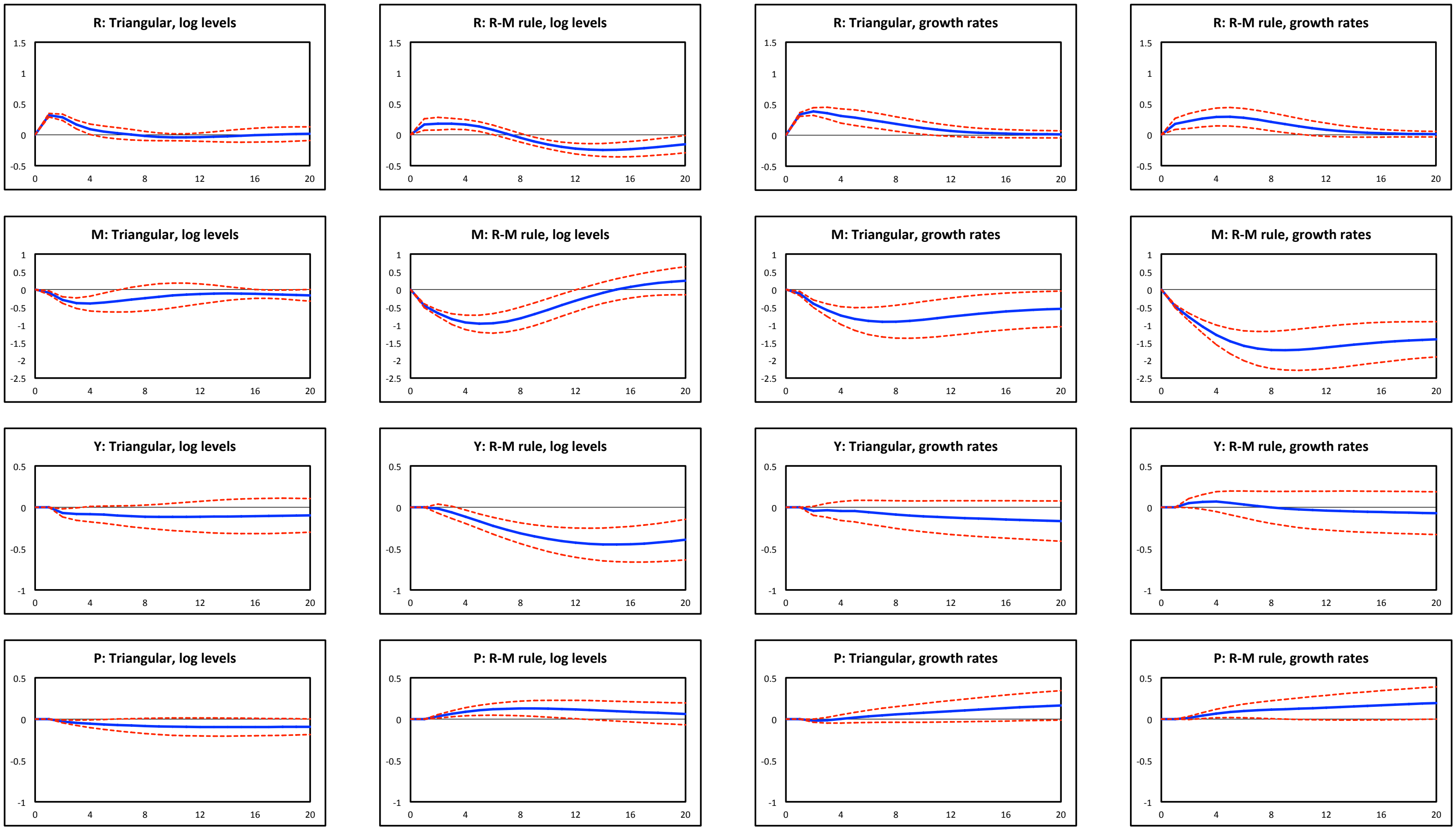


Figure 5. Impulse Responses, Middle Subsample: 1984:1 - 1999:4. Each column shows the percentage-point response of the federal funds rate (R), Divisia M1 (M), real GDP (Y), and the GDP deflator (P) to a one-standard-deviation monetary policy shock, identified using either the triangular model or the model with an interest rate-money policy rule and estimated with data either in log levels or growth rates. Dashed lines provide plus-and-minus one standard error bands.

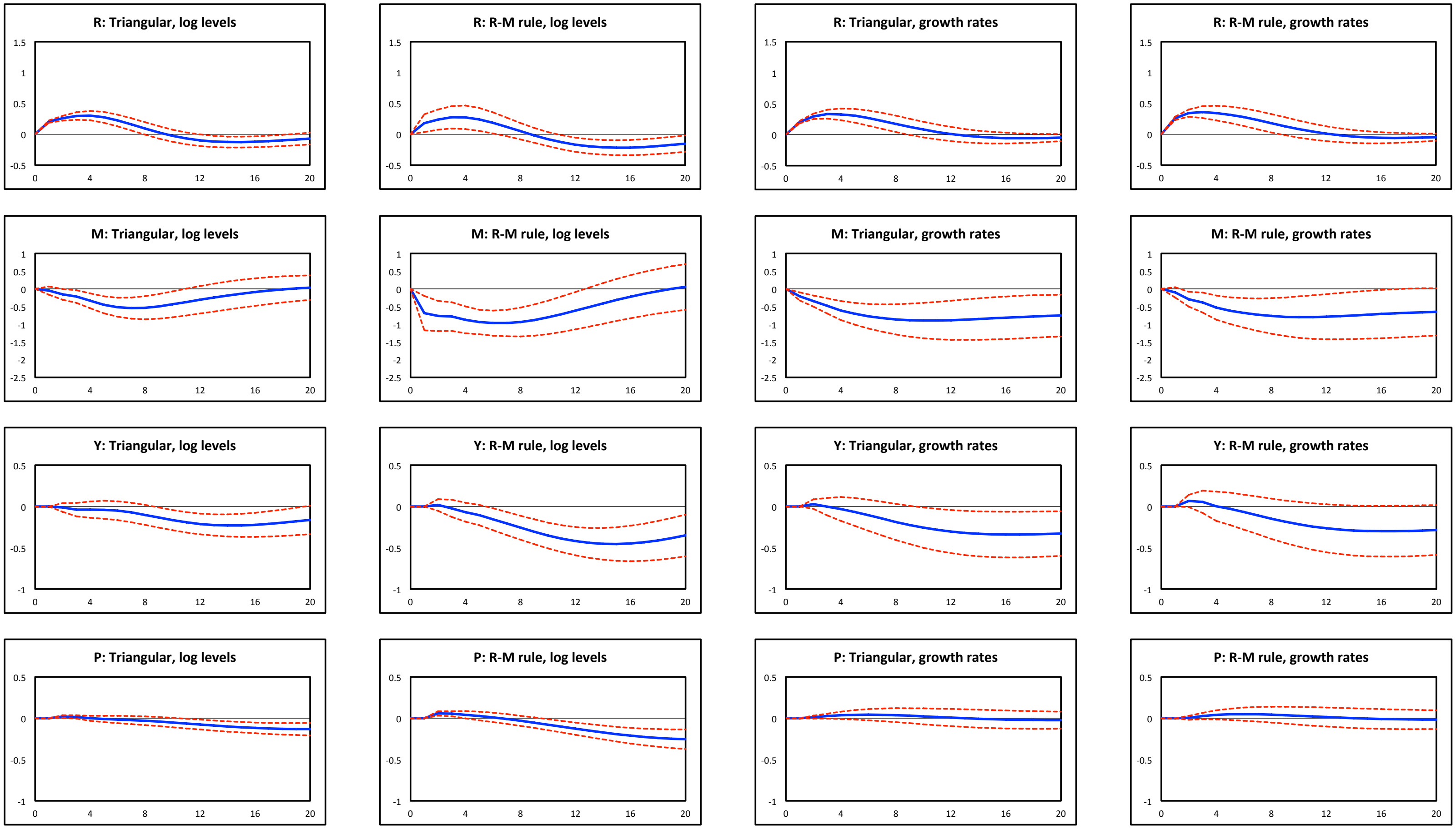


Figure 6. Impulse Responses, Recent Subsample: 2000:1 - 2013:4. Each column shows the percentage-point response of the federal funds rate (R), Divisia M1 (M), real GDP (Y), and the GDP deflator (P) to a one-standard-deviation monetary policy shock, identified using either the triangular model or the model with an interest rate-money policy rule and estimated with data either in log levels or growth rates. Dashed lines provide plus-and-minus one standard error bands.