INSTABILITY: MONETARY AND REAL

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Abstract: Fifty years ago, Friedman and Schwartz presented evidence of pro-cyclical movements in the money stock, exhibiting a lead over corresponding movements in output, found in historical monetary statistics for the United States. Very similar relationships appear in more recent data. To see them clearly, however, one must use Divisia monetary aggregates in place of the Federal Reserve's official, simple-sum measures. One must also split the data sample to focus, separately, on episodes before and after 1984 and on a new episode of instability beginning in 2000. A structural VAR draws tight links between Divisia money and output during each of these three periods.

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Money and Business Cycles: Intellectual Trends and Data Problems

Fifty years ago, Milton Friedman and Anna 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, Robert 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 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 developed by Goodfriend and King (1997), Woodford (2003), and Gali (2008), 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,

[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 (2011) for a comprehensive discussion of Fisher's influence on Friedman's monetary economics.

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 greatly hindered by the lack of quality data on the money stock itself. In 1980, William 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 (2013) 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. Yet despite Barnett's critique and the evidence provided by Belongia and Hendrickson, the Federal Reserve continues to publish data only on simple-sum measures of the money supply.

Measurement problems associated with these 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

[2] Nelson (2008) represents one attempt to re-establish the role of money in determining the long-run, or steady-state, rate of inflation in the New Keynesian model.

[3] Laidler (2013) presents an overview of "three revolutions" in macroeconomic thought, which are relevant to the theme of this paper.

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 measures but the Fed's aggregation procedures fail to make any adjustment for this phenomenon. As a result, a modest institutional change that remains invisible to virtually all bank customers and therefore has done little if anything to change the demand for monetary assets has introduced massive distortions into the official monetary statistics themselves.

Against this backdrop, several very recent events motivate – and permit – us to 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. First and most obviously, the financial crisis of 2008 and the severe and prolonged economic downturn that followed brought to a sudden close the extended period of U.S. macroeconomic stability that had become known popularly as the "Great Moderation." This episode ended, however, without a large disturbance that might resemble the aggregate technology shock in a real business cycle model. And although Ireland (2011) and Del Negro, Giannoni, and Schorfheide (2013) use New Keynesian models to track, with some degree of success, the data during and after the crisis, it still seems fair to say that the underlying causes of the "Great Recession" and slow recovery remain uncertain. Friedman and Schwartz's (1963a, 1963b) analysis covers episodes – again, most notably, the Great Depression – featuring financial disruptions and cyclical downturns that to many observers seem to resemble those from 2008, raising the question as to whether the same patterns linking money to output in their data might re-appear in the most recent statistics.

Second, and related, the Federal Reserve responded to the deepening crisis in 2008 by lowering its federal funds rate target to a range between 0 and 0.25 percent, where it has remained ever since. As emphasized by Barnett (2012), with the interest rate associated most closely with monetary policy in the New Keynesian model locked up against its lower bound, it becomes natural to ask whether measures of the money supply can be used, instead, to gauge the additional impact that "unconventional" policies, especially the Federal Reserve's program of "large scale asset purchases," are having on the economy. Finally, and thankfully, alternatives to the Federal Reserve's official, simple-sum M1 and M2 measures that use Barnett's (1980) procedures to aggregate the values of diverse monetary assets and that correct, as well, for the purely statistical effects of sweep programs have very recently been constructed and made publicly available by Richard Anderson and Barry Jones working at the Federal Reserve Bank of St. Louis and by Barnett and his associates at the Center for Financial Stability in New York. These new monetary aggregates, described by Anderson and Jones (2011) and Barnett, Liu, Mattson, and van den Noort (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.

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 1980, when NOW accounts became available nationwide and paid interest, however, simple-sum M1 fell victim to the Barnett (1980) Critique.[4] 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 M1 Monetary Services Index constructed by Anderson and Jones (2011), which we call "MSI M1," and the

[4] The "Barnett Critique" is the conjecture that the failure to find significant relations between the quantity of money and aggregate 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).

Divisia M1 aggregate constructed by Barnett, Liu, Mattson, and van den Noort (2013), which we refer to as "Divisia M1."

Importantly, both the MSI and Divisia measures of M1 add back to the official statistics an estimate of funds transferred from checking to savings accounts by automated sweep programs. In addition, both MSI M1 and Divisia M1 are Divisia aggregates of the type proposed by Barnett (1980). As explained by Barnett, Liu, Mattson, and van den Noort (2013), however, the MSI and Divisia measures differ 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. (2013) argue that the choice of the benchmark rate, though important 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, matters much less if one's focus remains on the quantity aggregate itself. Indeed, we find this in all of our results below: Each of the "MSI" aggregates behaves quite similarly to the corresponding "Divisia" aggregate. Still, to highlight their robustness and to acknowledge the joint contributions of Anderson, Jones, and Barnett, we report results from both sets of data.

In addition to the M1 aggregates, we also 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 (noninstitutional) money market mutual fund shares, together with the MSI and Divisia counterparts from the St. Louis Fed and 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 time deposit component from M2 but adds institutional money market 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; MSI and Divisia versions of this aggregate are also described by Anderson and Jones

(2011) and Barnett, Liu, Mattson, and van den Noort (2013). 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 extended this analysis below by considering the MSI and Divisia MZM aggregates as well and by including data through the financial crisis, Great Recession, and slow recovery that has followed.

The Data

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 data of 1967:1 is dictated by the availability of the MSI and 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 2013:2 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. The top panel presents dramatic evidence of the distortions introduced into the simple-sum M1 aggregate by the Federal Reserve's failure to correct these official figures for the effects of sweep programs during the 1990s. 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 are near eight percentage points. These graphs highlight the empirical relevance of Barnett's (1980) critique of simple-sum monetary aggregation and echo Belongia (1996) and Hendrickson's (2013) findings that "measurement matters" for empirical work in monetary economics.

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 Hodrick-Prescott (1997) filter with smoothing parameter set equal to 1600 and recovering the cyclical component. Figure 2 plots four of the resulting series: For two measures of money – Divisia M1 and M2 – and for output and prices. Graphically, both monetary measures seem to follow procylical 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.

Table 1 takes a first step in quantifying these relationships 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. For each monetary aggregate and each macroeconomic variable, the peak, positive correlation is highlighted in yellow. Overall, the numbers suggest that the links between money and the business cycle, though still present, may have weakened since Friedman and Schwartz studied them. For money and output, the correlations are always larger for the MSI and Divisia aggregates than they are for the simple-sum measures, but peak at only around 0.30 or 0.40 when money is lagged by three or four quarters. For money and prices, again, the correlations are larger for the MSI and Divisia aggregates compared to the simple sums, peaking between 0.40 and 0.58 when money is lagged by two-and-a-half to three years. As we are about to see, however, these modest full-sample correlations mask important changes that appear across different episodes when the full sample is partitioned.

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.[5] The top panel

[5] See Hetzel (2008) for a detailed historical account of this period, including a description of how the Federal Reserve's practice of smoothing interest rates – keeping them low during recessions and raising them only gradually during recoveries and expansions – led both to the

shows much stronger correlations between all measures of money and output at much shorter lags of only one to two quarters. Even for this early subsample, the MSI and 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 0.69 through 0.85 all occurring within the first year.

Table 2 shows a tighter statistical relation between cyclical movements in money and prices, as well. The largest correlations are again for the MSI and Divisia aggregates, which peak between 0.64 and 0.82 when money is lagged by two to three years. 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, first over output and then over prices, is at least suggestive of a causal role for money in generating business cycles during the late 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.

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. The two panels on the right-hand side of figure 2 clearly show diminished volatility in both output and prices during this period, while the two panels on the left-hand side just as clearly show signs of increased volatility, especially in the 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 these years paid little attention to the behavior of the money supply.

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cyclical fluctuations in money growth associated with "stop-go" and to the longer-run upward trend in the inflation rate.

Further signs appear in table 3, where the correlations for this period are generally smaller than their counterparts from table 2. Still, there are several details worth mentioning. First, in virtually all cases, the correlations between the MSI and Divisia monetary aggregates and either output or prices are noticeably higher than those between the simple-sum aggregates and the macroeconomic variables. As emphasized by Belongia (1996) and Hendrickson (2013), 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. Second, while the correlations shown in table 3 for this middle subsample are smaller than those in table 2 for the earlier period, they are – like those in table 2 – larger than the ones from the full sample reported in table 1. Thus, 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 MSI and Divisia aggregates, the peak correlations between money and output range from 0.34 to 0.43 and the peak correlations between money and prices range from 0.41 to 0.73. There is certainly more noise in the money supply during this early period of the Great Moderation, but not enough to completely obscure relations to macroeconomic fluctuations. Third, the lead of money over output and prices lengthens during this period, with peak money-output correlations appearing when money is lagged by one-and-a-half to two years and peak money-price correlations when money is lagged by three-and-a-half to four years.

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 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, but before, during, and after the financial crisis of 2008 – the most severe of its kind since the Great Depression – this difficulty would seem to loom especially large. This problem occurs 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 five years. To cite the most striking but potentially most misunderstood example: The quantity of reserves supplied to the banking system, as reported by the Federal Reserve Board in its H.3 statistical release, increased from slightly less than $46 billion to over $2 trillion – hence, by a factor of more than 40 – between August 2008 and June 2013. However, the Federal Reserve also began paying interest on reserves during that period. As explained by Ireland (2013), 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.

Nevertheless, all measures of money exhibit unusual – and volatile – behavior since 2000. The two panels of figure 3, for instance, zoom in on the movements in the cyclical components of Divisia M1 and M2 shown previously in figure 2, to focus more specifically on the recent subsample. Divisia M1, in particular, peaked in the fourth quarter of 2004 and followed a sharp downward trajectory through the middle of 2008. This measure of money bounced back in early 2009, but then resumed its downward trend in 2010 before recovering once again. With regard to the effects of 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, but only towards end, of the brief QE2 episode, and have been largely flat since QE3 began. Among the lessons of this figure is that gauging the stance of monetary policy by the level of interest rates or the size of 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 upward movements in the money supply.

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 2013:2, hence covering completely 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 seven or eight quarters, and with the broader M2 and MZM aggregates, the largest correlations appear when money is lagged by 12 to 15 quarters. On the other hand, the magnitudes of the money-output correlations also increase markedly, ranging from 0.67 to 0.76 and thereby nearly matching 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 many of the numbers reported in the bottom panel of table 4 are even larger than they were in table 2 for the earliest, pre-1984 subsample.

Particularly noteworthy are the correlations between MSI and Divisia M1 and both output and prices since 2000. The correlation between real GDP and Divisia M1 lagged seven quarters is 0.68; the correlation between the GDP deflator and Divisia M1 lagged 11 quarters is 0.83. By way of comparison, King and Watson (1996) single out the nominal interest rate on Treasury bills as a strong, inverse leading indicator for output based on a correlation, computed with data running from 1947 through 1992, of −0.74 when the interest rate is lagged six quarters. Here, in the most recent data, Divisia M1 appears to be almost as strong a leading indicator for output and an even stronger leading indicator for prices.

Towards 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 and 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) by associating monetary policy disturbances with statistical innovations to the funds rate and will also reassure readers that the important role that our results assign to the money stock is not simply due to the exclusion of interest rates from the analysis. 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 money supply from those to money demand. Finally, following the standard practice established by Sims (1992), we include a measure CP_t of commodity prices – the CRB/BLS spot index compiled by the Commodity Research Bureau – in the VAR as well. Also following standard practice in the literature on structural VARs, we let output, the price level, money, and commodity prices enter the model in log-levels, while the federal funds rate and the Divisia user cost measures enter as decimals and in annualized terms so that a federal funds rate conventionally quoted at an annual rate of 5 percent, for example, appears even in our quarterly dataset as a reading of

R_t = 0.05.

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

$$X_t = [P_t \quad Y_t \quad CP_t \quad R_t \quad M_t \quad U_t]'$$

the structural model takes the form

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

where μ is a 6 x 1 vector of coefficients, each $\Phi_j, j = 1,2,...,q,$ is a 6 x 6 matrix of coefficients,

B is a 6 x 6 matrix of coefficients, and ε_t is a 6 x 1 vector of serially and mutually

uncorrelated structural disturbances, normally distributed with zero means and

$$E\varepsilon_t\varepsilon_t' = I. \tag{2}$$

The reduced form associated with (1) is

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

where the 6 x 1 vector of zero-mean disturbances

$$x_t = [p_t \quad y_t \quad cp_t \quad r_t \quad m_t \quad u_t]'$$

is such that

$$Ex_t x_t' = \Sigma. \tag{4}$$

Comparing (1) and (2) to (3) and (4) reveals that the structural and reduced-form disturbances are linked via

$$Ax_t = \varepsilon_t,$$

where

$$A = B^{-1}.$$

The same comparison implies that

$$BB' = \Sigma. \tag{5}$$

Equation (5) highlights the identification problem: Since the covariance matrix Σ for the reduced-form innovations has only 21 distinct elements, at least 15 restrictions must be imposed on the elements of B or its inverse A in order to identify the structural disturbances from the information contained in the reduced form. Here, we solve this problem by applying a combination of zero restrictions and linear constraints to the elements of A.[6] Our parameterization has

$$A = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ 0 & 0 & 0 & a_{44} & a_{45} & 0 \\ -a_{55} & a_{52} & 0 & 0 & a_{55} & a_{56} \\ -a_{65} & 0 & 0 & a_{64} & a_{65} & a_{66} \end{bmatrix} \quad (6)$$

The first three rows in (6) identify a set of non-monetary disturbances through timing assumptions, similar to those used elsewhere throughout the literature on recursive VARs.[7] In particular, rows one and two allow aggregate output and the price level to respond contemporaneously to the shocks reflected in their own statistical innovations but only with a one-period lag to all other shocks. Row three, meanwhile, assumes that commodity prices react immediately to every shock hitting the economy.

The last three rows of (6) draw more heavily on theory, so as to model the monetary system in more detail. Row four describes a monetary policy rule of the form

$$a_{44} r_t + a_{45} m_t = \varepsilon_t^{mp} \quad (7)$$

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[6] Two other recent papers take different, but complementary, approaches to modeling, statistically, the links between Divisia money, output, and prices. El-Shagri, Giesen, and Kelly (2012) identify monetary policy shocks in a VAR that includes a Divisia monetary aggregate by imposing sign restrictions as suggested by Faust (1998) and Canova and De Nicolo (2002). Anderson, Chauvet, and Jones (2013) estimate a multivariate regime-switching model that allows for distinct permanent and transitory components in each series. Both of these studies provide further evidence associating real with monetary instability.

[7] See Stock and Watson (2001) for an introductory discussion of recursive versus structural vector autoregressions. Keating, Kelly, and Valcarcel (2013) report results from using various recursive identification schemes to identify monetary policy shocks in VARs that include Divisia money.

proposed first by Sims (1986) and used more recently by Leeper and Roush (2003) and Belongia and Ireland (2012b), 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. Row five represents a money demand relation

$$a_{55}(m_t - p_t) + a_{52}y_t + a_{56}u_t = \varepsilon_t^{md}, \tag{8}$$

linking 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 (7) and (8), our model distinguishes between shocks to money supply and shocks to money demand, first, by invoking the quantity theoretic proposition that "money supply" refers to nominal money whereas "money demand" pertains to real money balances and, second, by applying Belongia's (2006) insight to include the interest rate in the money supply rule but not the money demand equation and the user cost of money in the money demand equation but not the money supply rule.[8] Finally, row six of (6) provides the equation

$$a_{64}r_t + a_{65}(m_t - p_t) + a_{66}u_t = \varepsilon_t^{ms}, \tag{9}$$

describing 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 (2012a) and Ireland (2013) incorporate this "monetary system" in dynamic, stochastic,

[8] Output also appears in the money demand equation and not the monetary policy rule, helping to distinguish between these two relations as well, but this seems less essential in light of previous results from Leeper and Roush (2003) and Belongia and Ireland (2012b), which show that little improvement in statistical fit is obtained when the policy rule (7) is expanded to include both prices and output.

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 (9) 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) outlines methods for estimating structural VARs, like ours, via maximum likelihood. He shows, in particular, that even with the restrictions imposed on A in (7), maximum likelihood estimates of the elements of μ and $\Phi_j, j = 1, 2, ..., q,$ can still be found simply by applying ordinary least squares to each of the equations in the reduced form (3). Then, with Σ computed as suggested by (4) as the covariance matrix of the reduced-form innovations, the parameters of A can be estimated by maximizing

$$\ln\left(|A|^2\right) - \text{trace}\left[\left(A'A\right)\Sigma\right].$$

Table 5 shows maximum likelihood estimates of the key coefficients from the matrix A, obtained in this way for each of the three sample periods considered earlier. To make the table easier to read, only the estimated equations (7)-(9) with direct economic interpretations are shown, and each of these equations is re-normalized, with a single variable having a unitary coefficient on the left-hand side: the interest rate in the case of the monetary policy rule (7), real money in the case of the money demand equation (8), and the user cost of money in the case of the expression (9) describing the monetary system. The brevity of each subsample period, coupled with the rapid expansion in the number of autoregressive parameters as the number of lags of each variable included in the VAR increases, dictated our choice of $q = 2$ in each case.

For all three subsample periods, nominal money enters the right-hand side of the monetary policy rule with the expected, positive coefficient, reflecting the workings of a traditional liquidity effect through which a policy tightening increases the interest rate and decreases the money supply. The user cost variable enters the money demand equation with the expected, negative sign for all three periods, and output enters with a positive coefficient, except for the most recent subsample, where it is negative but small. This last result might indicate that the simple money demand specification in (8) cannot fully capture the flow of funds back into the federally insured components of M1 that took place, just as output was falling most sharply, in 2008 and 2009. Across all three samples, the estimated monetary system equation associates a rise in the federal funds rate with an increase in the user cost of money; real money balances enter the equation with the expected, positive sign except for the early subsample, where the estimated coefficient is negative, but again quite small. With only a couple of minor exceptions, therefore, the estimated coefficients in all three equations for all three sample periods line up with our intuition regarding the impact effects of changes in Federal Reserve policy, the behavior of the households and firms that demand monetary services, and the workings of the private financial system that creates liquid deposits and holds reserves.

Figure 4 plots the impulse responses of the model's four key macroeconomic variables – the interest rate, money, output, and the price level – to a one-standard deviation monetary policy shock that appears in equation (7) of the structural VAR. The differences observed across subsamples are striking, and echo the findings from our earlier, reduced-form analysis of shifting correlations.

In the figure's left-most column, a monetary policy shock during the early subsample that runs from 1967 through 1983 is associated with a sharp increase of more than 85 basis points in the federal funds rate that decays over a two-year period. The money supply also falls on impact, but unlike the interest rate does not fully recover: During this period, the VAR associates monetary policy shocks with permanent changes in the money supply. Output falls sharply as well, starting three quarters after the disturbance, and bottoms out after seven quarters. The price level declines after a longer lag, with the largest response observed in the fifth year. Altogether, these impulse responses for the early subsample trace out the set of effects traditionally associated with monetary policy disturbances in accounts dating back to Hume's (1777): An unanticipated, permanent decrease in the money supply leads to a transitory rise in the interest rate, a transitory fall in output, and a permanent decline in prices. Fully consistent, as well, with the tight correlations between lagged money, output, and prices shown previously in table 2, these impulse responses support Hetzel's (2008) characterization of how the Federal Reserve's stop-go monetary policy generated both macroeconomic instability and a rising trend in inflation from the middle 1960s through the late 1970s.

The impulse responses in the figure's center column, estimated with data from the Great Moderation, appear much different. There, an identified monetary policy shock leads to a much smaller increase in the nominal interest rate, with the federal funds rate rising by only about 20 basis points on impact. The effect on the money supply is larger, but more gradual, than it appears in the earlier subsample. Consistent with the longer lags between money and output suggested by the correlations in table 3, the decline in output shown for the middle period in figure 4 occurs more gradually and does not begin to reverse itself until the fourth year after the shock. The price level rises, slightly but persistently, after a monetary policy shock during this middle subsample. This counterintuitive response could be another manifestation of the "price puzzle" that is often observed in VAR results.[9] On the other hand, it is interesting to note that for this subsample only, the decline in the money supply that follows a monetary policy shock eventually reserves itself; when extended, in fact, the impulse response in the figure's second row shows that 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 increases the money supply in the long run. According to these impulse responses, Federal Reserve policy was remarkably successful at stabilizing prices, even as it remained a source of instability in output, during the period of the Great Moderation.

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[9] Note that the rise in prices following an identified monetary policy shock occurs, in this case, even though a measure of commodity prices is included in the VAR. We found, in fact, that the rise in prices continues to appear even when the monetary policy rule (7) is expanded to include the commodity price variable, as in the specifications used by Gordon and Leeper (1994) and Leeper and Zha (2003).

The right-most column of figure 4 can be summarized by saying that monetary policy shocks for the most recent period, since 2000, have had effects quite similar to, but noticeably larger than, those during the Great Moderation. The federal funds rate rises by 30 basis points after a contractionary shock; the money supply falls more persistently, and never reverses itself as it does in the 1984-1999 period. Output bottoms out in the fourth year after the shock and the price level declines persistently, beginning in the second year and continuing even after five years have passed. Like the correlations from table 4, these impulse responses suggest that Federal Reserve policy has been a source of heightened instability in output and renewed instability in prices during these most recent years.

Table 6 examines the VAR's implications in a different way, by reporting the percentage of the forecast error variance in aggregate output or the price level that the estimated model attributes to the identified monetary policy shock in (7) at various horizons over the three distinct sample periods. Consistent, once more, with both the reduced-form correlations in tables 2 through 4 and the impulse responses in figure 4, the variance decompositions in table 6 show that the effects of monetary policy on output and prices get felt most strongly after a considerable lag.[10] Once again, monetary policy appears as an important source of instability in output during all three sample periods, accounting for between 20 and 40 percent of the forecast error variance in real GDP three to five years ahead. And, once again, it appears that the Federal Reserve succeeded in stabilizing prices only during the 1984-1999 period: The fraction of the forecast error variance in the GDP deflator five years ahead attributed to monetary policy shocks exceeds one half for the earlier, 1967-1983, episode and one third for the later, 2000-2013, subsample.

[10] 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 between money supply and money demand.

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. Results from Ireland (2003), however, based on comparisons of the quantitative implications of dynamic, stochastic, general equilibrium models with and without price rigidities, suggest that some form of monetary nonneutrality drawing causal links between movements in money and subsequent movements in output will be needed to account for the longer lags evident in tables 3 and 4 and in figure 4. 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.

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 (2012) 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 (2012), 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 further theoretical analysis of how the private banking system acts alongside the

Federal Reserve to create liquid assets, perhaps along the same lines as Sustek (2010), Belongia and Ireland (2012a), and Ireland (2013), 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), Tatom (2011), Barnett (2012), and Hetzel (2012) 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 an period of relative tranquility, re-entered a phase of both monetary and real instability? Only time will tell, but the possibility, suggested by the echoes of Friedman and Schwartz's (1963a) earlier findings in our own, that monetary policymakers have once again gone off track by neglecting the behavior of the money supply, should be enough to motivate renewed interest in understanding the relations between money and the business cycle.

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Table 1. Full Sample: 1967:1 - 2013:2

A. Correlation of HP filtered log real GDP 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	-0.06	-0.06	-0.05	-0.03	-0.01	0.02	0.05	0.09	0.12	0.16	0.19	0.20	0.21	0.20	0.18	0.13	0.06
MSI M1	-0.16	-0.15	-0.13	-0.11	-0.07	-0.03	0.00	0.05	0.10	0.17	0.22	0.25	0.28	0.28	0.28	0.24	0.17
Divisia M1	-0.17	-0.16	-0.13	-0.11	-0.07	-0.03	0.01	0.06	0.12	0.18	0.24	0.28	0.31	0.31	0.31	0.26	0.18
Simple-Sum M2	-0.11	-0.16	-0.19	-0.20	-0.20	-0.18	-0.14	-0.08	0.00	0.10	0.18	0.25	0.30	0.33	0.34	0.28	0.18
MSI M2	-0.26	-0.26	-0.24	-0.21	-0.16	-0.10	-0.05	0.03	0.11	0.21	0.29	0.34	0.38	0.39	0.38	0.31	0.19
Divisia M2	-0.27	-0.26	-0.25	-0.22	-0.17	-0.12	-0.06	0.01	0.11	0.21	0.31	0.37	0.42	0.43	0.43	0.37	0.25
Simple-Sum MZM	-0.05	-0.04	-0.02	0.01	0.05	0.10	0.14	0.18	0.21	0.24	0.26	0.26	0.26	0.23	0.19	0.10	-0.03
MSI MZM	-0.16	-0.14	-0.13	-0.10	-0.05	-0.01	0.04	0.09	0.14	0.20	0.25	0.28	0.30	0.29	0.27	0.20	0.09
Divisia MZM	-0.17	-0.15	-0.13	-0.09	-0.05	0.00	0.04	0.09	0.14	0.20	0.25	0.28	0.30	0.29	0.27	0.21	0.10

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	0.06	0.12	0.18	0.24	0.29	0.32	0.33	0.32	0.28	0.21	0.13	0.03	-0.08	-0.18	-0.27	-0.33	-0.36
MSI M1	0.08	0.17	0.25	0.32	0.37	0.41	0.41	0.39	0.34	0.26	0.16	0.04	-0.09	-0.21	-0.31	-0.39	-0.43
Divisia M1	0.08	0.16	0.24	0.31	0.36	0.39	0.40	0.37	0.32	0.24	0.14	0.02	-0.11	-0.23	-0.33	-0.40	-0.44
Simple-Sum M2	0.23	0.31	0.36	0.39	0.39	0.36	0.30	0.21	0.08	-0.07	-0.22	-0.37	-0.48	-0.56	-0.58	-0.55	-0.46
MSI M2	0.39	0.48	0.54	0.57	0.58	0.54	0.46	0.35	0.20	0.04	-0.14	-0.31	-0.46	-0.58	-0.65	-0.66	-0.63
Divisia M2	0.40	0.49	0.55	0.58	0.58	0.54	0.46	0.35	0.19	0.02	-0.16	-0.34	-0.50	-0.62	-0.68	-0.70	-0.66
Simple-Sum MZM	0.22	0.22	0.20	0.17	0.13	0.06	-0.02	-0.11	-0.21	-0.33	-0.44	-0.53	-0.59	-0.62	-0.61	-0.56	-0.47
MSI MZM	0.33	0.37	0.40	0.41	0.39	0.34	0.26	0.17	0.04	-0.10	-0.25	-0.38	-0.50	-0.59	-0.63	-0.63	-0.58
Divisia MZM	0.37	0.41	0.44	0.44	0.42	0.37	0.28	0.18	0.05	-0.10	-0.25	-0.39	-0.51	-0.60	-0.64	-0.64	-0.59

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

A. Correlation of HP filtered log real GDP 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	-0.04	-0.22	-0.37	-0.48	-0.54	-0.58	-0.62	-0.59	-0.51	-0.36	-0.18	-0.01	0.19	0.41	0.64	0.77	0.74
MSI M1	-0.10	-0.27	-0.42	-0.53	-0.60	-0.66	-0.71	-0.68	-0.58	-0.41	-0.20	-0.01	0.21	0.42	0.64	0.78	0.77
Divisia M1	-0.10	-0.27	-0.42	-0.53	-0.59	-0.65	-0.70	-0.66	-0.55	-0.36	-0.14	0.05	0.27	0.47	0.68	0.80	0.76
Simple-Sum M2	-0.20	-0.31	-0.38	-0.42	-0.42	-0.37	-0.29	-0.14	0.03	0.21	0.37	0.50	0.60	0.68	0.71	0.64	0.47
MSI M2	-0.39	-0.47	-0.50	-0.50	-0.46	-0.39	-0.31	-0.17	0.01	0.21	0.39	0.54	0.69	0.78	0.85	0.82	0.66
Divisia M2	-0.35	-0.41	-0.44	-0.43	-0.40	-0.34	-0.27	-0.14	0.02	0.22	0.40	0.55	0.69	0.77	0.83	0.80	0.64
Simple-Sum MZM	-0.24	-0.23	-0.19	-0.12	-0.04	0.04	0.13	0.24	0.37	0.49	0.59	0.64	0.69	0.68	0.62	0.47	0.25
MSI MZM	-0.37	-0.40	-0.40	-0.37	-0.32	-0.24	-0.16	-0.03	0.12	0.30	0.46	0.59	0.71	0.78	0.81	0.75	0.56
Divisia MZM	-0.39	-0.41	-0.40	-0.37	-0.31	-0.23	-0.15	-0.03	0.12	0.30	0.46	0.59	0.71	0.78	0.82	0.77	0.58

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	-0.25	-0.05	0.15	0.33	0.50	0.62	0.71	0.74	0.68	0.59	0.42	0.22	0.02	-0.17	-0.34	-0.48	-0.59
MSI M1	-0.20	0.00	0.21	0.39	0.56	0.69	0.79	0.82	0.77	0.67	0.52	0.32	0.12	-0.09	-0.29	-0.46	-0.60
Divisia M1	-0.20	0.01	0.21	0.40	0.56	0.69	0.78	0.80	0.74	0.63	0.46	0.26	0.05	-0.15	-0.34	-0.51	-0.64
Simple-Sum M2	0.19	0.34	0.45	0.53	0.57	0.55	0.49	0.37	0.21	0.02	-0.18	-0.38	-0.55	-0.66	-0.70	-0.69	-0.62
MSI M2	0.34	0.49	0.60	0.69	0.72	0.70	0.62	0.49	0.30	0.10	-0.12	-0.32	-0.51	-0.66	-0.75	-0.78	-0.76
Divisia M2	0.33	0.47	0.57	0.65	0.68	0.65	0.57	0.44	0.26	0.06	-0.15	-0.35	-0.53	-0.66	-0.74	-0.77	-0.75
Simple-Sum MZM	0.37	0.43	0.43	0.43	0.38	0.27	0.14	0.00	-0.17	-0.34	-0.48	-0.60	-0.70	-0.74	-0.70	-0.63	-0.53
MSI MZM	0.36	0.49	0.56	0.62	0.64	0.59	0.49	0.34	0.16	-0.04	-0.23	-0.40	-0.56	-0.69	-0.75	-0.77	-0.74
Divisia MZM	0.40	0.51	0.58	0.63	0.64	0.58	0.48	0.34	0.16	-0.04	-0.23	-0.41	-0.57	-0.69	-0.76	-0.78	-0.75

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

A. Correlation of HP filtered log real GDP 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	-0.16	-0.13	-0.09	-0.04	0.00	0.06	0.11	0.18	0.22	0.24	0.23	0.20	0.18	0.13	0.08	0.01	-0.05
MSI M1	-0.26	-0.21	-0.14	-0.08	0.00	0.10	0.18	0.28	0.35	0.39	0.39	0.36	0.34	0.28	0.22	0.14	0.05
Divisia M1	-0.26	-0.21	-0.13	-0.07	0.01	0.11	0.20	0.31	0.38	0.42	0.43	0.40	0.37	0.31	0.25	0.16	0.07
Simple-Sum M2	-0.32	-0.19	-0.08	0.00	0.05	0.09	0.10	0.10	0.08	0.04	-0.01	-0.06	-0.05	-0.03	-0.03	-0.04	-0.04
MSI M2	-0.53	-0.41	-0.26	-0.13	0.00	0.13	0.22	0.30	0.34	0.34	0.29	0.21	0.16	0.09	0.02	-0.06	-0.14
Divisia M2	-0.55	-0.42	-0.27	-0.14	0.01	0.14	0.24	0.33	0.37	0.37	0.31	0.24	0.18	0.11	0.04	-0.04	-0.12
Simple-Sum MZM	-0.26	-0.19	-0.10	0.01	0.12	0.24	0.33	0.39	0.42	0.40	0.35	0.26	0.21	0.15	0.09	0.00	-0.12
MSI MZM	-0.38	-0.31	-0.22	-0.11	0.01	0.13	0.23	0.32	0.37	0.38	0.34	0.27	0.22	0.16	0.10	0.01	-0.09
Divisia MZM	-0.41	-0.34	-0.23	-0.12	0.01	0.13	0.24	0.33	0.37	0.38	0.34	0.28	0.22	0.17	0.10	0.01	-0.09

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	0.16	0.24	0.29	0.33	0.34	0.33	0.30	0.26	0.19	0.10	-0.01	-0.14	-0.26	-0.37	-0.46	-0.52	-0.55
MSI M1	0.34	0.41	0.44	0.44	0.41	0.36	0.29	0.20	0.09	-0.04	-0.18	-0.32	-0.45	-0.55	-0.63	-0.68	-0.69
Divisia M1	0.33	0.39	0.41	0.41	0.37	0.32	0.25	0.16	0.05	-0.08	-0.21	-0.35	-0.47	-0.57	-0.64	-0.68	-0.69
Simple-Sum M2	0.45	0.36	0.28	0.18	0.09	0.01	-0.05	-0.08	-0.11	-0.15	-0.17	-0.19	-0.19	-0.18	-0.17	-0.14	-0.12
MSI M2	0.67	0.69	0.69	0.64	0.57	0.49	0.38	0.27	0.14	-0.01	-0.16	-0.31	-0.45	-0.54	-0.61	-0.64	-0.64
Divisia M2	0.70	0.73	0.72	0.67	0.60	0.51	0.40	0.29	0.15	-0.01	-0.17	-0.32	-0.47	-0.56	-0.64	-0.68	-0.68
Simple-Sum MZM	0.34	0.33	0.28	0.21	0.12	0.03	-0.07	-0.14	-0.22	-0.30	-0.38	-0.45	-0.51	-0.55	-0.56	-0.53	-0.47
MSI MZM	0.48	0.52	0.52	0.48	0.42	0.34	0.24	0.14	0.03	-0.10	-0.23	-0.35	-0.47	-0.55	-0.61	-0.64	-0.62
Divisia MZM	0.52	0.56	0.55	0.52	0.46	0.37	0.27	0.17	0.05	-0.08	-0.22	-0.35	-0.47	-0.56	-0.62	-0.65	-0.64

Table 4. Recent Subsample: 2000:1 - 2013:2

A. Correlation of HP filtered log real GDP 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	-0.14	0.03	0.21	0.37	0.49	0.57	0.64	0.68	0.70	0.69	0.66	0.58	0.49	0.33	0.14	-0.07	-0.25
MSI M1	-0.21	-0.03	0.16	0.32	0.45	0.54	0.62	0.67	0.70	0.70	0.67	0.62	0.53	0.39	0.21	0.02	-0.16
Divisia M1	-0.23	-0.04	0.15	0.31	0.44	0.53	0.60	0.65	0.68	0.68	0.66	0.60	0.51	0.37	0.20	0.01	-0.14
Simple-Sum M2	0.65	0.69	0.71	0.65	0.54	0.40	0.24	0.05	-0.09	-0.17	-0.25	-0.33	-0.38	-0.44	-0.46	-0.49	-0.49
MSI M2	0.39	0.51	0.62	0.66	0.67	0.64	0.57	0.45	0.33	0.25	0.15	0.04	-0.07	-0.20	-0.31	-0.43	-0.52
Divisia M2	0.40	0.52	0.62	0.66	0.67	0.63	0.56	0.44	0.32	0.24	0.14	0.03	-0.08	-0.21	-0.33	-0.45	-0.54
Simple-Sum MZM	0.75	0.76	0.74	0.68	0.59	0.48	0.34	0.15	-0.05	-0.24	-0.43	-0.60	-0.71	-0.76	-0.77	-0.73	-0.67
MSI MZM	0.60	0.67	0.72	0.72	0.68	0.60	0.50	0.35	0.19	0.04	-0.12	-0.27	-0.41	-0.51	-0.59	-0.64	-0.66
Divisia MZM	0.60	0.67	0.72	0.72	0.67	0.60	0.50	0.34	0.18	0.03	-0.12	-0.27	-0.41	-0.52	-0.60	-0.64	-0.66

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	0.39	0.51	0.62	0.70	0.77	0.81	0.80	0.73	0.63	0.49	0.34	0.15	-0.04	-0.24	-0.39	-0.47	-0.47
MSI M1	0.34	0.49	0.61	0.70	0.79	0.84	0.84	0.79	0.70	0.57	0.43	0.25	0.06	-0.14	-0.30	-0.40	-0.42
Divisia M1	0.33	0.48	0.60	0.70	0.79	0.83	0.83	0.78	0.69	0.57	0.43	0.26	0.07	-0.13	-0.29	-0.37	-0.37
Simple-Sum M2	0.66	0.60	0.49	0.37	0.25	0.12	-0.02	-0.16	-0.31	-0.42	-0.50	-0.57	-0.60	-0.61	-0.55	-0.40	-0.17
MSI M2	0.74	0.77	0.76	0.71	0.66	0.56	0.42	0.26	0.08	-0.08	-0.22	-0.36	-0.49	-0.59	-0.62	-0.55	-0.39
Divisia M2	0.74	0.76	0.75	0.70	0.64	0.55	0.41	0.25	0.07	-0.09	-0.23	-0.37	-0.50	-0.60	-0.64	-0.56	-0.40
Simple-Sum MZM	0.69	0.61	0.51	0.38	0.23	0.04	-0.15	-0.35	-0.54	-0.70	-0.80	-0.85	-0.84	-0.79	-0.69	-0.53	-0.31
MSI MZM	0.77	0.74	0.69	0.61	0.51	0.35	0.18	-0.01	-0.21	-0.38	-0.52	-0.64	-0.72	-0.74	-0.71	-0.59	-0.39
Divisia MZM	0.77	0.73	0.69	0.61	0.50	0.35	0.18	-0.01	-0.21	-0.39	-0.53	-0.64	-0.72	-0.74	-0.72	-0.60	-0.39

Table 5. Maximum Likelihood Estimates from a Structural VAR

A. Early Subsample: 1967:1 - 1983:4

Monetary Policy	r = 1.95m
Money Demand	m - p = 0.25y - 0.23u
Monetary System	u = 1.37r - 0.07(m - p)

B. Middle Subsample: 1984:1 - 1999:4

Monetary Policy	r = 2.99m
Money Demand	m - p = 0.80y - 1.53u
Monetary System	u = 2.10r + 0.12(m - p)

C. Recent Subsample: 2000:1 - 2013:2

Monetary Policy	r = 0.26m
Money Demand	m - p = -0.14y - 1.83u
Monetary System	u = 3.48r + 0.62(m - p)

Table 6. Forecast Error Variance Decompositions

	1967:1 - 1983:4		1984:1 - 1999:4		2000:1 - 2013:2	
Quarters Ahead	Real GDP	GDP Deflator	Real GDP	GDP Deflator	Real GDP	GDP Deflator
2	0.2	0.4	0.1	2.0	0.1	7.3
4	16.8	0.9	2.4	7.3	0.5	5.1
8	31.7	1.2	15.9	11.8	6.2	2.6
12	31.0	17.6	28.7	12.5	21.1	9.6
16	30.6	43.2	36.6	12.1	33.4	23.9
20	30.4	52.3	41.2	11.4	34.9	36.0

Each entry indicates the percentage of the forcast error variance in real GDP or the GDP deflator due to monetary policy shocks, identified by a structural vector autoregression.

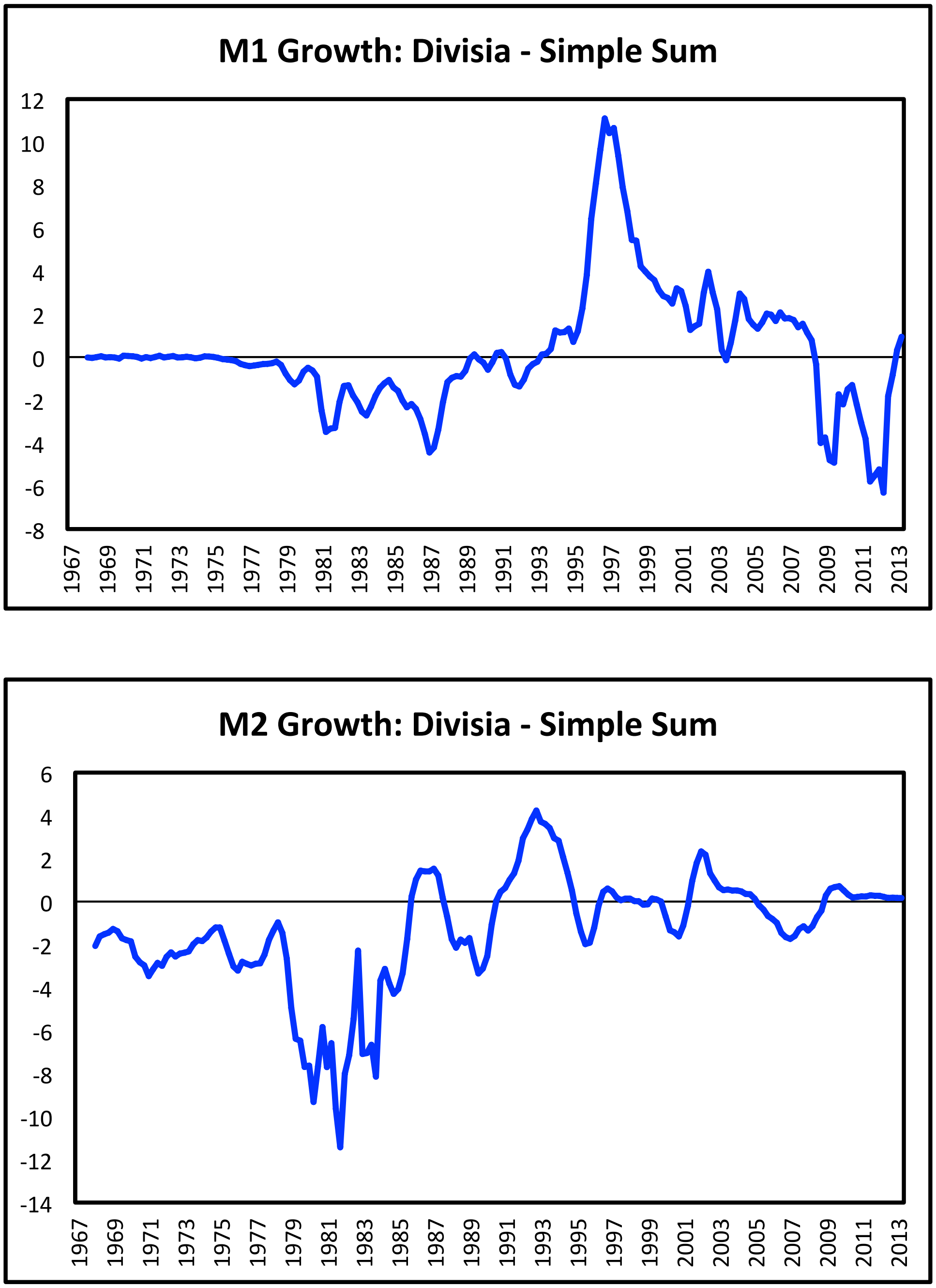

Figure 1. Differences in year-over-year growth rates of Divisia and simple-sum monetary aggregates.

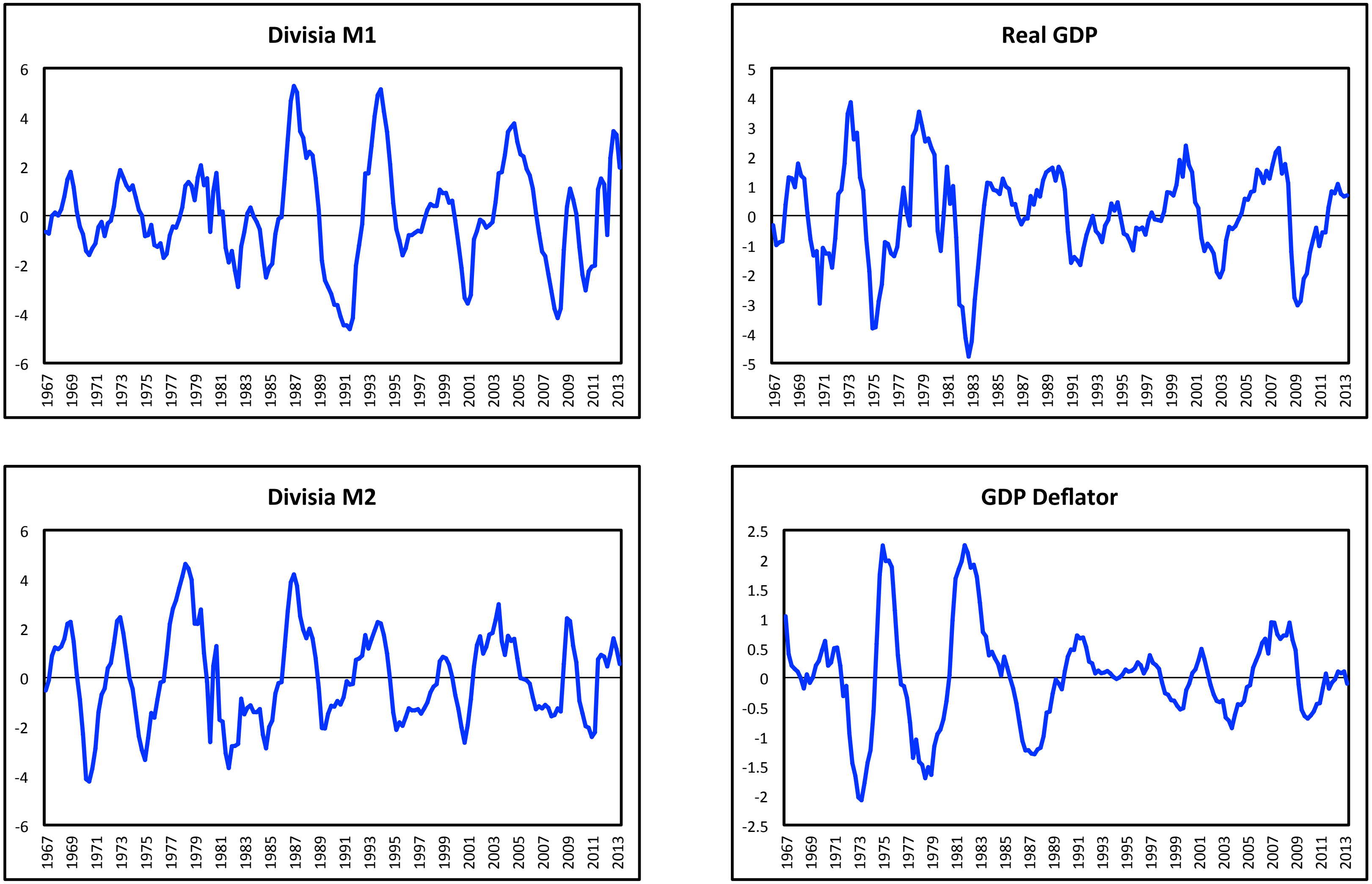

Figure 2. Cyclical components of Divisia money, output, and prices. Computed with the Hodrick-Prescott filter. All variables in logs.

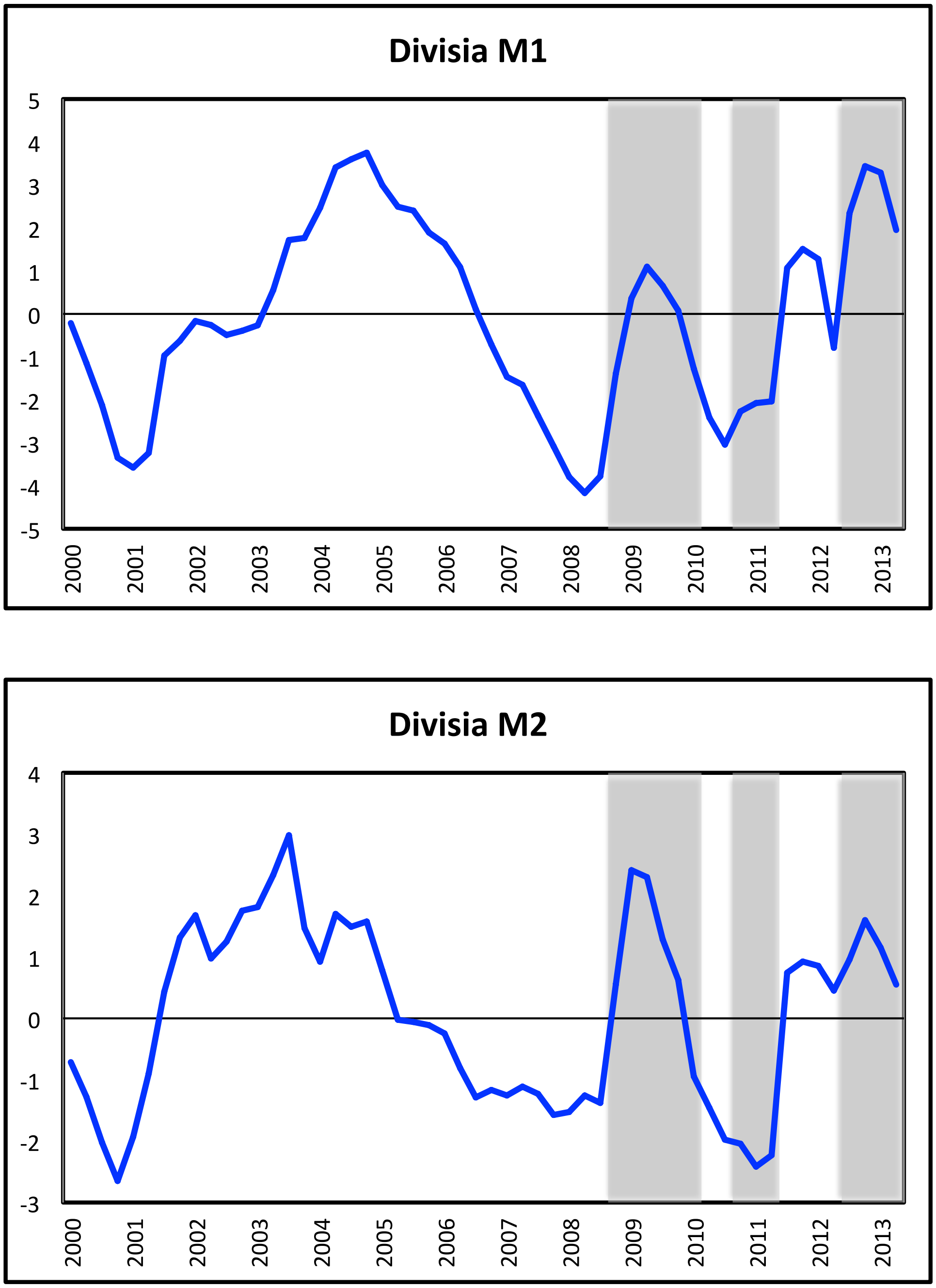

Figure 3. Cyclical components of Divisia money, computed with the Hodrick-Prescott filter. Episodes of Large Scale Asset Purchases by the Federal Reserve are shaded.

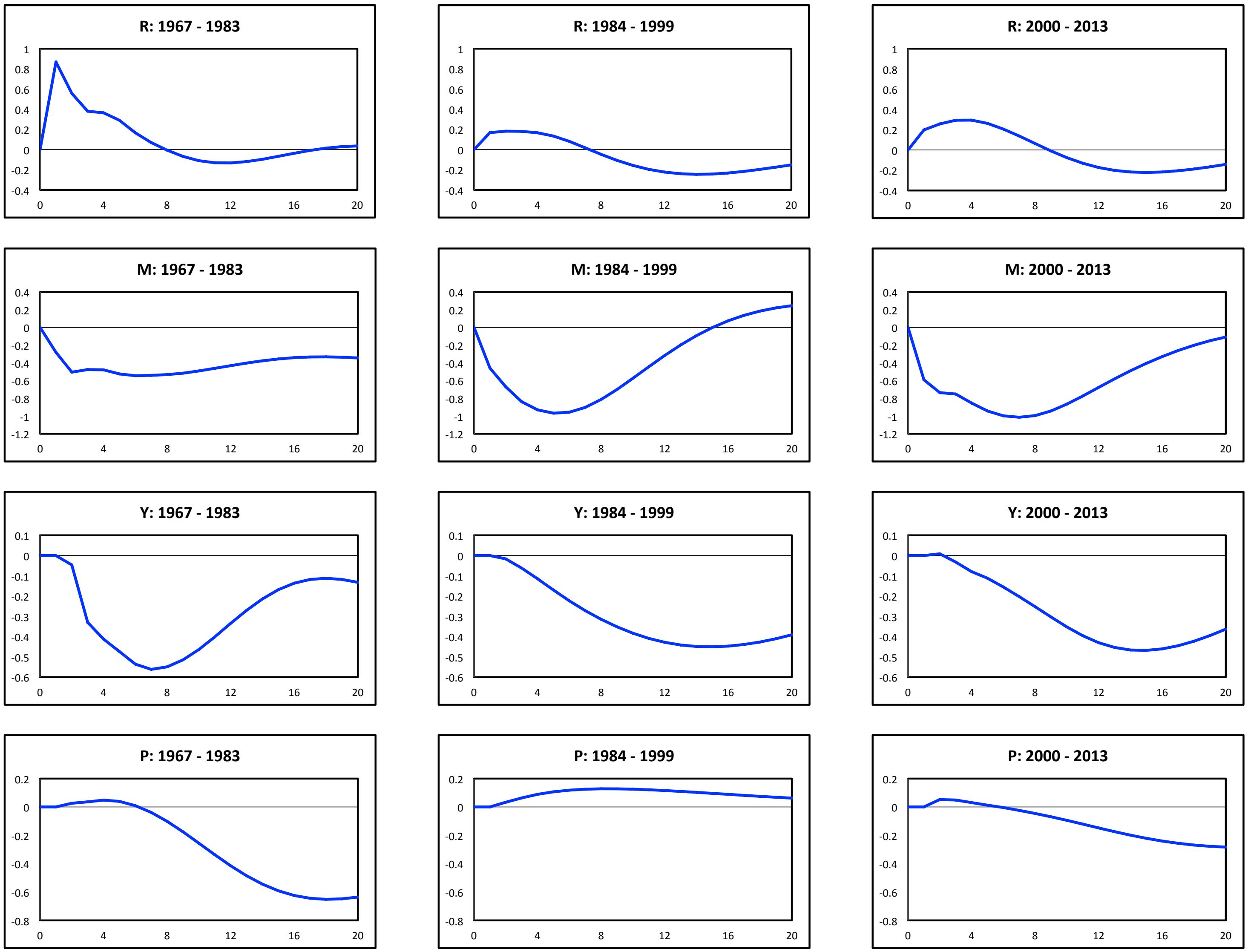

Figure 4. Impulse responses of the federal funds rate (R), Divisia M1 (M), real GDP (Y), and the GDP deflator (P) to a one-standard-deviation monetary policy shock, identified from a structural vector autoregression.