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INTEREST RATES, MONEY, AND ECONOMIC ACTIVITY

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In this paper, we are motivated by the fact that little is known about the relative performance of broad and narrow Divisia monetary aggregates, and by recent work that tests and rejects the appropriateness of the aggregation assumptions that underlie the various monetary aggregates published by the Federal Reserve as well as a large number of monetary asset groupings suggested by earlier studies. We present a comprehensive comparison of narrow versus broad Divisia monetary aggregates within three classes of empirical models. We compute correlations between the cyclical components of Divisia monetary aggregates at different levels of aggregation and the cyclical component of industrial production. We test for Granger causality running from the Divisia aggregates to industrial production and various other measures of real economic activity. We also reestimate a structural vector autoregression based on earlier work by Leeper and Roush [(2003) *Journal of Money, Credit, and Banking* 35, 1217–1256] and Belongia and Ireland [(2015) *Journal of Business and Economic Statistics* 33, 255–269; (2016) *Journal of Money, Credit and Banking* 48, 1223–1266], modifying that earlier work using monthly rather than quarterly data and extending it, both using broad as well as narrower Divisia monetary aggregates and by allowing for Generalized autoregressive conditional heteroskedasticity (GARCH) behavior in the structural shocks.

Keywords: Divisia Monetary Aggregates, Narrow Money, Broad Money

1. INTRODUCTION

The mainstream approach to monetary policy is based on the new Keynesian model and is expressed in terms of interest rate rules of the type proposed by Taylor (1993). In this approach, the operating target of monetary policy is the interest rate on overnight loans between banks, such as the federal funds rate in the USA, and there is no role for the aggregate quantity of money in the monetary transmission mechanism. However, in the aftermath of the global financial crisis, central banks around the world have used (and some are still

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using) unconventional monetary policies, and the use of such policies, often referred to as "quantitative easing," has sparked considerable debate with respect to the effectiveness of the traditional interest rate targeting approach to monetary policy. In fact, as Belongia and Ireland (2015, p. 255) recently put it, "the new policy initiatives can be characterized simply as conventional attempts to increase money growth."

This raises the issue of whether there is a useful role of the aggregate quantity of money in monetary policy and business cycle analysis. In answering this question, Leeper and Roush (2003, p. 1) argue that the main reason that money has conspicuously disappeared from monetary policy analyses since the beginning of the Taylor rule era is that "in the most widely used models of monetary policy, the money stock is redundant for determining output and inflation once the short-term nominal interest rate is present. The near-universal adoption of interest rate instruments by central banks, coupled with the belief that actual central bank behavior is well modeled by a policy rule that sets the interest rate as a function of only output and inflation, has led to an emphasis on theoretical models in which money supply is infinitely elastic." However, in answering the same question, as McCallum and Nelson (2011, p. 147) put it, "too much in the reaction to problems in measuring money has taken the form of abandoning the analysis of monetary aggregates, and too little has taken the form of more careful efforts at improved measurement."

In this regard, over the years, a large number of articles have shown that most of the puzzles and paradoxes in monetary economics have been produced by the use of simple-sum monetary aggregates and are resolved by use of aggregation theoretic monetary aggregates, such as Barnett's (1980) superlative Divisia monetary aggregates. See, for example, Barnett and Chauvet (2011), Hendrickson (2014), Serletis and Gogas (2014), Belongia and Ireland (2014, 2015, 2016, 2018), and Ellington (2018), among others. In fact, Belongia and Ireland (2015, p. 268) "call into question the conventional view that the stance of monetary policy can be described with exclusive reference to its effects on interest rates and without consideration of simultaneous movements in the monetary aggregates." They argue that properly measured monetary aggregates, such as the new Center for Financial Stability (CFS) Divisia monetary aggregates, can and should play an important role (either as intermediate targets or indicator variables) for the conduct of monetary policy, in addition to that of the short-term nominal interest rate.

The main objective of this paper is to examine the relative information content of Divisia measures of money and interest rates in explaining key macroeconomic variations and to provide a comparison between narrow and broad Divisia measures of money. We are motivated by the fact that little is known about the relative performance of broad and narrow Divisia money measures and by the need to solve the "Barnett critique"—the measurement problems associated with the failure to find significant relations between money and key macroeconomic variables. In this regard, Jadidzadeh and Serletis (2019) address the issue of optimal monetary aggregation in the context of a large demand system, encompassing the full range of monetary assets. They provide evidence, based on disaggregated

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monetary demand responses, that the simple-sum monetary aggregates used by central banks around the world are inconsistent with neoclassical microeconomic theory. Their statistical tests also reject the necessary and sufficient conditions for all the money measures published by the Federal Reserve as well as a large set of null hypotheses that would be consistent with the existence of subaggregates of various subsets of liquid assets. Their tests support and reinforce Barnett's (2016) assertion that we should use, as a measure of money, the broadest Divisia M4 monetary aggregate prepared by the CFS, as opposed to narrower aggregates such as Divisia M1 or Divisia M2.

We provide a comprehensive comparison of narrow versus broad Divisia monetary aggregates within three classes of empirical models. First, we compute correlations between the cyclical components of those various monetary aggregates and the cyclical components of industrial production. Second, we test for Granger causality running from the Divisia monetary aggregates to industrial production and various other measures of real economic activity. Third, we reestimate a structural vector autoregressive (VAR) model that identifies monetary policy shocks (MPS) with innovations in the federal funds rate, as in Leeper and Roush (2003) and Belongia and Ireland (2015, 2016). In doing so, we allow for GARCH behavior in the structural shocks, and as in these articles, we allow the money supply to enter into the description of the monetary policy rule in order to provide a more theoretically consistent description of money demand. However, unlike Leeper and Roush (2003), who conduct their analysis using monthly data (from 1959:1 to 2001:6) and the simple-sum M2 measure of money, and Belongia and Ireland (2015, 2016), who use quarterly data (from 1967:1 to 2013:4) and limit their comparison between narrow simple-sum and Divisia money measures at the M1, M2, and MZM levels of monetary aggregation, we conduct our empirical analysis with monthly data (from 1967:1 to 2018:3) and provide a comparison between narrow Divisia money measures—at the M1, M2, M2M, MZM, and ALL levels of aggregation—and broad Divisia money measures—at the M3, M4-, M4 levels of aggregation.

The rest of the paper is organized as follows. Section 2 discusses the data and provides some graphical representations of narrow and broad Divisia money measures. Section 3 describes the Kydland and Prescott (1990) methodology and the new Hamilton (2018) filter that we use in our investigation of the cyclical behavior of narrow and broad Divisia money measures. The results of the cyclical correlation analysis are also presented in this section. In Section 4, we describe the Granger causality testing methodology that we use in our investigation of the information content of interest rates and (narrow and broad) Divisia money measures, and we present the empirical results. Section 5 presents a simple six-variable structural VAR with GARCH(1,1) errors and the identification scheme used to distinguish between MPS, money demand shocks (MDS), and monetary system shocks (MSS). Section 6 presents the empirical results in terms of impulse response functions and forecast error variance decompositions. The final section briefly concludes regarding the implications of our research for monetary theory and the conduct of monetary policy.

2. THE DATA

We use monthly data for the USA from January 1967 to March 2018. This sample period is dictated by the availability of the Divisia monetary aggregates. In particular, we use the new Divisia monetary aggregates (and their corresponding user costs), maintained within the CFS program Advances in Monetary and Financial Measurement, called CFS Divisia aggregates and documented in detail in Barnett *et al*. (2013). We make comparisons between narrow Divisia money measures—those at the M1, M2, M2M, MZM, and ALL levels of monetary aggregation—and broad Divisia money measures—those at the M3, M4-, M4 levels of monetary aggregation. As noted by Barnett *et al*. (2013), the components of the US Divisia monetary aggregates closely mirror their simple-sum counterparts provided by the Federal Reverse. However, the Fed stopped reporting the (simple-sum) M3 monetary aggregate in March 2006 and the broadest money supply measure that now reports is (simple-sum) M2, which is not very broad. In this regard, the Divisia M4 monetary aggregate includes five more components than the Divisia M2—institutional money market funds, long-term deposits, repurchase agreements, commercial paper, and treasury bills. As Hanke (2019, p. 57) recently put it, "these components are important because they all serve, in varying degrees, as money. To exclude them from a measure of money would be to exclude a great deal." For a detailed discussion of the data and the methodology for the calculation of the monetary aggregates, see Barnett *et al*. (2013) and http://www.centerforfinancialstability.org.

We use the federal funds rate as the monetary policy variable. Our measure of real output is the industrial production index, but we also use a number of alternative indicators of real economic activity. These are capacity utilization, civilian employment, the unemployment rate, housing starts, personal income, personal income per capita, personal consumption expenditure, and personal consumption expenditure on durable goods. Other variables that we use are the consumer price index (CPI) and a commodity price index. With the exception of the commodity price index, all these other variables are taken from the St. Louis Federal Reserve Economic Data service. The commodity price index is the CRB/BLS spot index from Thompson Reuters. All data are in monthly frequency, seasonally adjusted, and (as already noted) cover the period from January 1967 to March 2018.

In Figures 1, 2, and 3, we present the logged levels of the narrow Divisia monetary aggregates, the broad Divisia monetary aggregates, and a combination of selected narrow and broad Divisia money measures, respectively. As can be seen, all the monetary aggregates trend steadily upward and follow slightly distinct paths. In Figure 1, Divisia M1 is clearly distinguishable from all the other narrow Divisia money measures since the 1980s. In relation to the broad money measures, the increases in M1 are particularly more pronounced and noticeable after the 2007–2008 global financial crisis (see Figure 3). Divisia M2, on the other hand, has lagged behind both the Divisia M1 and all the broad Divisia money measures for most of the sample period. As shown in Figure 4, Divisia M1 shows

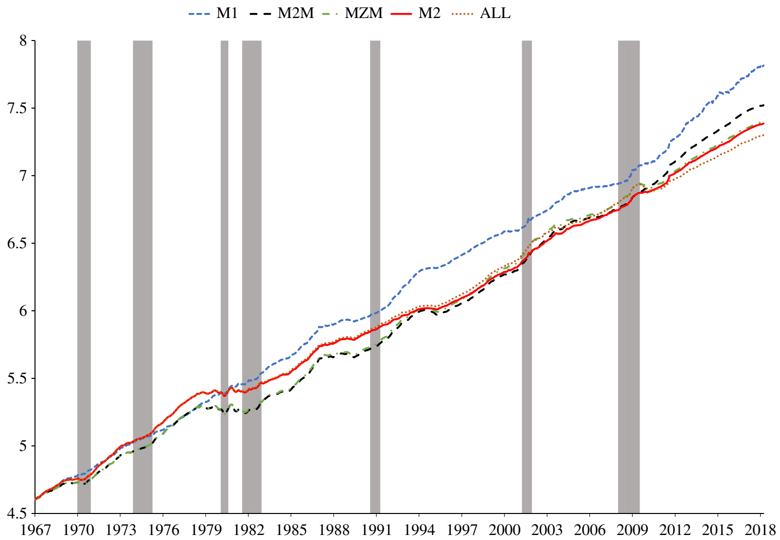

FIGURE 1. Logged levels of narrow Divisia monetary aggregates

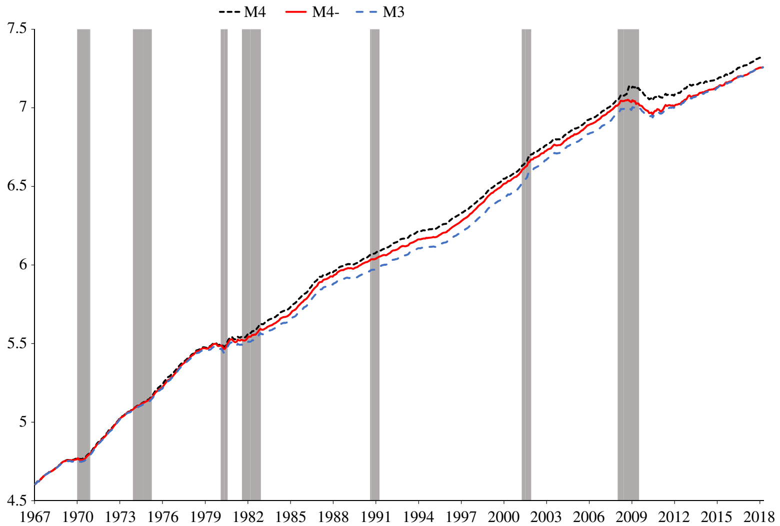

FIGURE 2. Logged levels of broad Divisia monetary aggregates

more variability in its monthly growth rate compared to all the other monetary aggregates. Figures 3 and 4 also show that during and after the global financial crisis, the narrow aggregates are growing faster than the broad aggregates. The general pattern in all the graphs is the persistent upward trend in the log levels and the significant variability in the growth rates, with the growth rate of the broad

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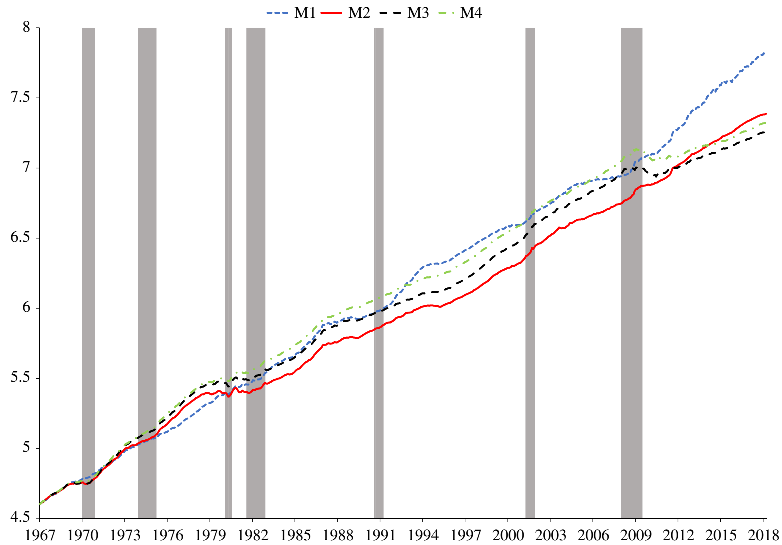

FIGURE 3. Logged levels of selected narrow and broad Divisia monetary aggregates

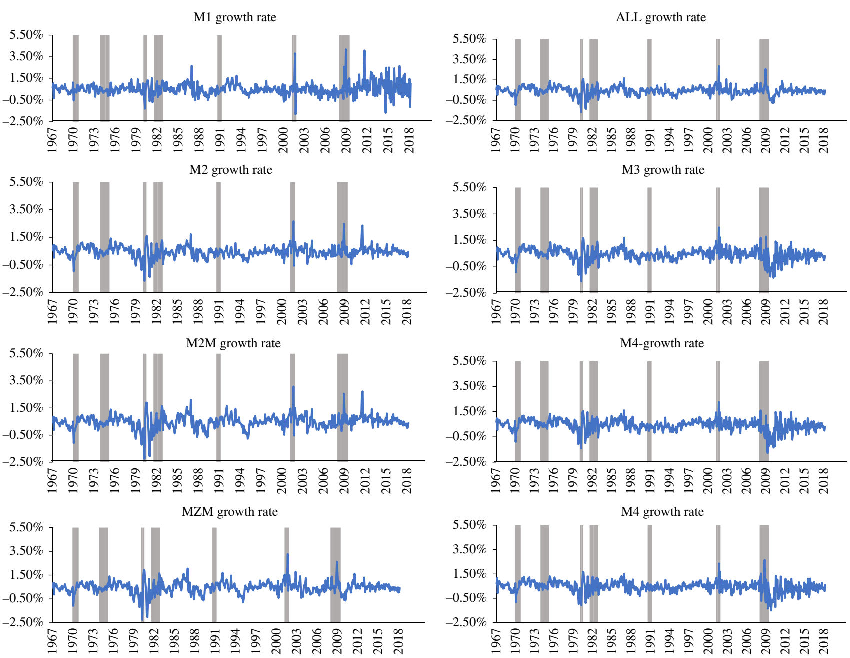

FIGURE 4. Divisia monetary aggregates monthly growth rates

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aggregates lagging the growth rate of the narrow aggregates in the aftermath of the global financial crisis.

3. THE CYCLICAL BEHAVIOR OF MONEY

In this section, we use the methodology suggested by Kydland and Prescott (1990) to investigate the cyclical properties of the narrow and broad Divisia monetary aggregates. In doing so, we use Hamilton's (2018) new regression filter, to extract the cyclical components, but also investigate the robustness of our results to alternative detrending methods and in particular to the use of the popular Hodrick and Prescott (1980) filter.

In particular, with monthly data, for a nonstationary time series, y_t, Hamilton (2018) suggests an OLS regression of y_t against four lags of itself shifted 24 months back, as follows:

$$y_t = \beta_0 + \beta_1 y_{t-24} + \beta_2 y_{t-25} + \beta_3 y_{t-26} + \beta_4 y_{t-27} + v_t.$$

The regression residuals, $\hat{v}_t$,

$$\hat{v}_t = y_t - \hat{\beta}_0 - \hat{\beta}_1 y_{t-24} - \hat{\beta}_2 y_{t-25} - \hat{\beta}_3 y_{t-26} - \hat{\beta}_4 y_{t-27}.$$

provide the cyclical component of the series. We can then investigate whether the cyclical component of a given Divisia monetary aggregate is correlated with the cyclical component of real output.

We measure the degree of cyclical comovement by the magnitude of the correlation coefficient

$$\rho(M_t, Y_{t+j}), \text{ for } j = -24, -18, 12, -9, -6, -3, -2, -1, 0, 1, 2, 3, 6, 9, 12, 18, 24$$

with all the variables being in logarithms. $\rho(M_t, Y_t)$ gives information on the degree of contemporaneous comovement. If $\rho(M_t, Y_t) > 0$, we say that M_t is procyclical, if $\rho(M_t, Y_t) < 0$, we say that M_t is countercyclical, and if $\rho(M_t, Y_t) = 0$, we say that M_t is acyclical. The cross-correlation coefficient, $\rho(M_t, Y_{t+j})$ for $j \neq 0$, gives information on the phase shift of M_t. If the absolute value of $\rho(M_t, Y_{t+j})$ is maximum for a positive, zero, or negative j, we say that M_t is leading the cycle by j periods, is synchronous, or is lagging the cycle by j periods, respectively.

We report the contemporaneous and cross-correlation coefficients between the cyclical component of each of the monetary aggregates and industrial production in Table 1. As can be seen, all the narrow Divisia monetary aggregates are acyclical (see panel A). However, as can be seen in panel B, the broad Divisia monetary aggregates are weakly procyclical. In Figures 5 and 6, we present the cyclical components of industrial production and Divisia M2 and Divisia M4, respectively. These figures clearly depict the acyclical behavior of narrow money measures and the weak procyclical movements of broad money measures. We also find that both the narrow and broad Divisia monetary aggregates lag the cycle of industrial production. Figures 5 and 6 quite obviously depict the lagging behavior for Divisia M2 and Divisia M4, respectively.

Table 1. Cyclical correlations between logged Divisia monetary aggregates and industrial production

	$\rho(x_t,\ y_{t+j}), j = -24, -18, -12, -9, -6, -3, -2, -1, 0, 1, 2, 3, 6, 9, 12, 18, 24$																
Series	$j=-24$	$j=-18$	$j=-12$	$j=-9$	$j=-6$	$j=-3$	$j=-2$	$j=-1$	$j=0$	$j=1$	$j=2$	$j=3$	$j=6$	$j=9$	$j=12$	$j=18$	$j=24$
A. Narrow money measures																	
Divisia M1	0.190	**0.287**	0.282	0.265	0.219	0.150	0.127	0.099	0.069	0.043	0.016	−0.011	−0.058	−0.089	−0.121	−0.187	−0.229
Divisia M2	0.111	0.282	**0.321**	0.309	0.267	0.192	0.160	0.124	0.087	0.054	0.021	−0.009	−0.054	−0.088	−0.120	−0.161	−0.134
Divisia M2M	0.240	0.379	**0.389**	0.356	0.292	0.193	0.152	0.107	0.061	0.019	−0.023	−0.061	−0.128	−0.182	−0.229	−0.272	−0.227
Divisia MZM	0.240	0.379	**0.389**	0.356	0.292	0.193	0.152	0.107	0.061	0.019	−0.023	−0.061	−0.128	−0.182	−0.229	−0.272	−0.227
Divisia ALL	0.035	0.166	**0.194**	0.189	0.167	0.125	0.107	0.086	0.065	0.049	0.033	0.021	0.026	0.036	0.041	0.039	0.060
B. Broad money measures																	
Divisia M3	−0.057	0.109	0.223	0.275	0.311	**0.319**	0.313	0.302	0.286	0.272	0.259	0.250	0.239	0.217	0.176	0.080	0.051
Divisia M4-	−0.092	0.083	0.223	0.294	0.352	0.383	**0.385**	0.381	0.372	0.366	0.357	0.350	0.347	0.323	0.272	0.145	0.077
Divisia M4	−0.057	0.079	0.148	0.177	0.191	**0.193**	0.190	0.186	0.177	0.168	0.161	0.160	0.175	0.188	0.183	0.151	0.139

Notes: Sample period, monthly data: 1969:04–2018:03. Cyclical components are obtained using the Hamilton (2018) filter.

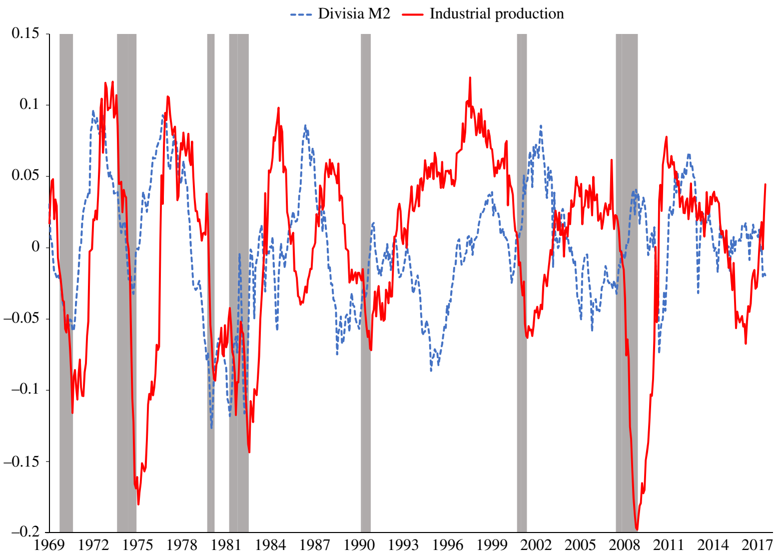

FIGURE 5. Cyclical components of Divisia M2 and industrial production

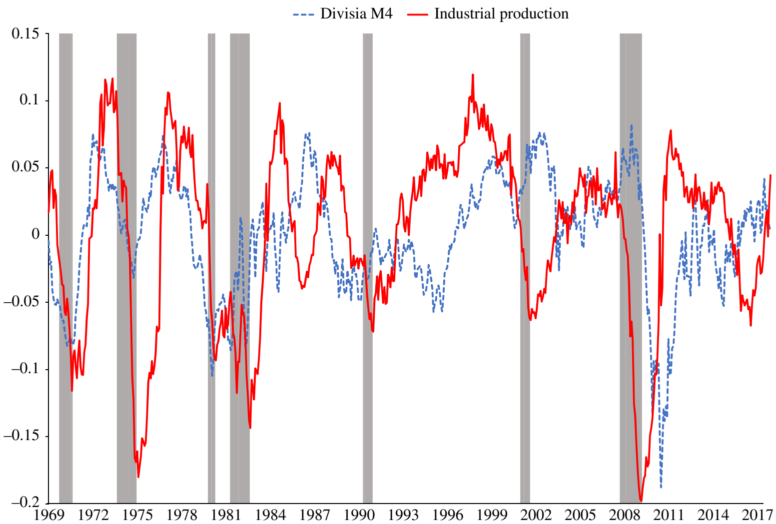

FIGURE 6. Cyclical components of Divisia M4 and industrial production

It is also worth noticing that the new Hamilton (2018) filter produces cyclical components that display more pronounced variability than the corresponding cyclical components obtained using the Hodrick and Prescott (1980) filter—see, for example, Online Appendix in Figure A1. Moreover, the Hamilton (2018) filter produces slightly higher cyclical correlations compared to those we find using the Hodrick and Prescott (1980) filter. We present the HP-based contemporaneous and cross-correlation coefficients between the cyclical component of each of the monetary aggregates and industrial production in Online Appendix Table A1, in the same fashion as those in Table 1 based on the Hamilton (2018) filter.

4. THE INFORMATION CONTENT OF MONEY

Having established the cyclical properties of the Divisia monetary aggregates, we next perform Granger causality tests to investigate the information content of each of the Divisia monetary aggregates in predicting real economic activities. We also assess the information content of the federal funds rate as the benchmark variable. In doing so, we follow Bernanke and Blinder (1992) and Belongia and Ireland (2015) and use the following regression equation

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{j=1}^{q} \theta_j X_{t-j} + \sum_{k=1}^{r} \lambda_k P_{t-k} + e_t, \quad (1)$$

where Y_t is a measure of real economic activity, X_t is a monetary policy variable (either the federal funds rate, R_t, or a monetary aggregate, M_t), and P_t is the CPI which acts as an adjustment variable to remove the effects of general prices from the estimates. Our measure of real output is industrial production, but we also use other measures of economic activity and in particular, total capacity utilization, civilian employment, the unemployment rate, housing starts, personal consumption expenditure, and consumption expenditure for durable goods. We test for Granger causality in the context of two arbitrarily chosen lag structures, $p = q = r = 6$ and $p = q = r = 12$, as well as for a flexible lag structure optimally chosen by the Akaike information criterion (AIC) after letting each of p, q, and r take values from 1 to 12 and running 1728 regressions. We report the Granger causality test results in Table 2. Each entry in the table represents the marginal significance level of the test statistic testing the null hypothesis that all lags of the monetary policy variable (the X variable in the above equation) can be excluded from the regression, that is, $\theta_j = 0$, $\forall\ j$. Therefore, smaller p-values indicate a stronger role for that monetary policy variable.

We tend to discount the results acquired using the fixed lags of 6 and 12 months and only discuss the results based on the AIC optimal lag structure (in the third panel of Table 2). As can be seen, the federal funds rate is informative for five of the nine measures of real activity. We also observe that the narrow money measures, except for Divisia M1, are informative in predicting three to five out of the nine measures of real economic activity used in this study; Divisia M1 is informative for predicting only one measure of real economic activity, the durable goods orders. Thus, the narrow Divisia money measures, except for Divisia M1, are at least as informative as the federal funds rate in predicting real economic activities. On the other hand, broad money measures, particularly Divisia M3 and Divisia M4-, are extremely informative and superior to the narrow Divisia money

TABLE 2. Granger causality test results with data in logged levels

Forecasted variable	Fed funds rate	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
	6 lags								
Industrial production	0.065	0.335	0.206	0.092	0.200	0.434	**0.003**	**0.005**	**0.020**
Capacity utilization	**0.031**	0.444	0.570	0.313	0.462	0.683	**0.031**	**0.040**	0.071
Employment	**0.005**	0.678	0.219	0.109	0.189	0.376	**0.026**	**0.019**	0.246
Unemployment rate	**0.012**	0.683	0.854	0.769	0.655	0.760	0.267	0.226	0.789
Housing starts	0.082	0.173	**0.015**	**0.005**	**0.005**	**0.013**	**0.000**	**0.000**	**0.014**
Personal income per capita	0.454	0.395	0.914	0.859	0.835	0.897	0.060	**0.018**	0.173
Personal income	0.446	0.467	**0.000**	0.910	0.901	0.942	0.106	**0.050**	0.232
Consumption	0.863	0.461	0.051	0.061	**0.023**	**0.018**	**0.001**	**0.000**	0.472
Durable goods orders	0.105	0.082	**0.006**	**0.007**	**0.004**	**0.005**	**0.000**	**0.000**	0.263
	12 lags								
Industrial production	0.263	0.640	0.672	0.575	0.669	0.825	**0.047**	**0.041**	0.104
Capacity utilization	0.094	0.523	0.924	0.833	0.766	0.868	0.143	0.108	0.157
Employment	0.172	0.528	0.086	**0.039**	0.148	0.298	0.051	**0.047**	0.155
Unemployment rate	0.146	0.777	0.629	0.582	0.634	0.697	0.777	0.757	0.986
Housing starts	**0.034**	0.313	**0.039**	**0.010**	**0.006**	**0.021**	**0.000**	**0.000**	**0.026**
Personal income per capita	0.694	0.613	0.885	0.872	0.829	0.839	0.192	**0.049**	0.404
Personal income	0.712	0.693	**0.000**	0.906	0.877	0.881	0.312	0.134	0.532
Consumption	0.982	0.633	0.102	0.084	**0.031**	**0.033**	**0.002**	**0.001**	0.255
Durable goods orders	0.320	0.173	**0.019**	**0.045**	**0.026**	**0.016**	**0.003**	**0.002**	0.141

TABLE 2. Continued

	AIC optimal lags								
Forecasted variable	Fed funds rate	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
Industrial production	**0.006**	0.366	0.051	**0.026**	0.074	0.161	**0.000**	**0.001**	**0.003**
Capacity utilization	**0.003**	0.227	0.184	0.161	0.147	0.136	**0.008**	**0.010**	**0.009**
Employment	**0.001**	0.076	**0.045**	**0.002**	**0.023**	0.158	**0.005**	**0.006**	0.055
Unemployment rate	**0.007**	0.209	0.433	0.343	0.395	0.508	0.633	0.634	0.690
Housing starts	**0.012**	0.189	**0.003**	**0.000**	**0.000**	**0.003**	**0.000**	**0.000**	**0.000**
Personal income per capita	0.974	0.234	0.485	0.345	0.270	0.436	**0.017**	**0.005**	0.096
Personal income	0.743	0.369	0.910	0.632	0.534	0.918	**0.021**	**0.009**	0.150
Consumption	0.587	0.231	**0.002**	**0.001**	**0.000**	**0.001**	**0.000**	**0.000**	0.191
Durable goods orders	0.089	**0.048**	**0.000**	**0.001**	**0.001**	**0.001**	**0.000**	**0.000**	0.073

Notes: Sample period, monthly data: 1967:01–2018:03. Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

measures and the federal funds rate. In particular, Divisia M3 and Divisia M4- have information content for predicting eight out of the nine measures of real economic activity, while with the Divisia M4 aggregate we are able to reject the null hypothesis of no causality only in three out of the nine measures. We find similar patterns of informativeness and superiority of the broad Divisia money aggregates over the federal funds rate and the narrow Divisia money aggregates when we run the regression in equation (1) using monthly growth rates and annual growth rates as opposed to the logged levels that we use in Table 2. In this regard, as noted by Christiano and Ljungqvist (1988), the results of Granger causality tests depend on data transformations, that is on whether the data is in log levels or growth rates. These additional robustness checks are reported in Tables 3 and 4. It is worth noticing that in Tables 3 and 4, the Divisia M4 monetary aggregate has information for predicting seven out of the nine measures of real activity, thus rendering our argument regarding the general superiority of broad money over narrow money even stronger. Thus, our results are robust and our general conclusion is consistent and invariant across such transformations of the data.

According to Sims (1980a) and Litterman and Weiss (1985), the predictive power of money tends to be absorbed by the interest rate. In particular, it was argued that in a VAR with money, output, prices, and the interest rate, causality from money to output was either nonexistent or very weak. Thus, we want to verify if the presence of the federal funds rate diminishes the predictive power of Divisia money measures or changes our conclusions in any way. To do so, we reestimate equation (1) while also controlling for the federal funds rate as follows:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{j=1}^{q} \theta_j M_{t-j} + \sum_{k=1}^{r} \lambda_k P_{t-k} + \sum_{\ell=1}^{s} \phi_\ell R_{t-\ell} + e_t. \quad (2)$$

We maintain the arbitrarily chosen lag lengths of 6 and 12 months but also allow for a flexible lag structure optimally chosen using the AIC after letting each of p, q, r, and s take values from 1 to 12 and running 20,736 regressions. The results are presented in Table 5 (using log levels), in Table 6 (using monthly growth rates), and in Table 7 (using annual growth rates). In all cases, the predictive power of the Divisia money measures does not diminish. In some cases, controlling for the federal funds rate actually improves the predictive power of the Divisia monetary aggregates, suggesting that Divisia money can be preferred to the federal funds rate as an indicator or intermediate target in the conduct of monetary policy. Moreover, broad Divisia money measures are still superior to narrow Divisia money measures. Our general conclusion that broad Divisia money measures are more informative than narrow Divisia money measures is also consistent with the conclusion of King and Plosser (1984) that narrow money tends to have weaker effect on real activities.

It should be noted that Friedman and Kuttner (1992) have called into question the predictive power of money in data from the post-1980 period. To investigate this issue, we reestimate equations (1) and (2) for the post-1980 sample of data

TABLE 3. Granger causality test results with monthly growth rates

Forecasted variable	Fed funds rate	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
	6 lags								
Industrial production	0.148	0.256	0.130	**0.047**	0.164	0.376	**0.002**	**0.002**	**0.007**
Capacity utilization	0.160	0.241	0.197	**0.039**	0.271	0.627	**0.007**	**0.013**	**0.015**
Employment	**0.046**	0.581	0.091	**0.045**	0.132	0.302	**0.024**	**0.020**	0.211
Unemployment rate	0.155	0.497	0.676	0.406	0.587	0.792	0.434	0.472	0.907
Housing starts	**0.023**	0.079	**0.006**	**0.001**	**0.001**	**0.006**	**0.001**	**0.003**	**0.038**
Personal income per capita	0.587	0.617	0.903	0.885	0.857	0.850	**0.049**	**0.019**	0.118
Personal income	0.621	0.596	0.901	0.876	0.850	0.841	**0.047**	**0.018**	0.109
Consumption	0.838	0.384	**0.013**	**0.018**	**0.003**	**0.002**	**0.000**	**0.000**	0.195
Durable goods orders	0.244	**0.026**	**0.002**	**0.002**	**0.001**	**0.001**	**0.001**	**0.000**	0.108
	12 lags								
Industrial production	0.155	0.338	0.642	0.473	0.519	0.731	**0.040**	**0.024**	0.081
Capacity utilization	0.116	0.310	0.754	0.440	0.668	0.900	0.103	0.072	0.167
Employment	0.309	0.343	**0.020**	**0.006**	**0.037**	0.105	**0.029**	**0.019**	0.066
Unemployment rate	0.448	0.319	0.414	0.295	0.493	0.625	0.689	0.733	0.983
Housing starts	**0.021**	0.272	**0.029**	**0.004**	**0.004**	**0.027**	**0.000**	**0.000**	**0.019**
Personal income per capita	0.665	0.939	0.942	0.951	0.952	0.941	0.239	0.091	0.377
Personal income	0.678	0.936	0.943	0.951	0.952	0.942	0.236	0.090	0.380
Consumption	0.989	0.613	0.110	0.053	**0.033**	0.063	**0.004**	**0.005**	0.307
Durable goods orders	0.314	0.080	**0.008**	**0.011**	**0.009**	**0.009**	**0.004**	**0.005**	0.123

	AIC optimal lags								
Industrial production	**0.002**	**0.045**	**0.012**	**0.002**	**0.008**	**0.047**	**0.000**	**0.000**	**0.001**
Capacity utilization	**0.004**	**0.027**	**0.018**	**0.001**	**0.014**	0.125	**0.002**	**0.007**	**0.003**
Employment	**0.005**	0.114	**0.008**	**0.001**	**0.006**	**0.044**	**0.007**	**0.010**	0.059
Unemployment rate	**0.023**	0.848	0.944	0.057	0.847	0.596	0.360	0.381	0.488
Housing starts	**0.004**	**0.039**	**0.002**	**0.000**	**0.000**	**0.005**	**0.000**	**0.000**	**0.009**
Personal income per capita	0.275	0.278	0.724	0.485	0.633	0.882	**0.006**	**0.002**	**0.024**
Personal income	0.486	0.266	0.706	0.472	0.662	0.912	**0.005**	**0.002**	**0.021**
Consumption	0.659	0.051	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.049**
Durable goods orders	0.232	**0.003**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.006**

Notes: Sample period, monthly data: 1967:02–2018:03. Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

TABLE 4. Granger causality test results with annual growth rates

Forecasted variable	Fed funds rate	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
					6 lags				
Industrial production	**0.010**	**0.009**	**0.001**	**0.000**	**0.002**	**0.009**	**0.000**	**0.000**	**0.001**
Capacity utilization	**0.005**	**0.004**	**0.001**	**0.000**	**0.003**	**0.017**	**0.000**	**0.002**	**0.003**
Employment	**0.022**	0.162	**0.027**	**0.005**	**0.033**	0.147	**0.017**	**0.016**	0.200
Unemployment rate	0.086	0.125	0.460	0.274	0.449	0.649	0.245	0.256	0.385
Housing starts	**0.008**	**0.008**	**0.000**	**0.000**	**0.000**	**0.001**	**0.000**	**0.000**	**0.001**
Personal income per capita	**0.014**	0.562	0.389	0.345	0.407	0.505	0.063	**0.037**	0.163
Personal income	**0.017**	0.573	0.491	0.370	0.416	0.503	0.065	**0.038**	0.161
Consumption	0.736	0.145	**0.014**	**0.007**	**0.003**	**0.006**	**0.002**	**0.001**	0.427
Durable goods orders	**0.011**	**0.033**	**0.002**	**0.000**	**0.000**	**0.001**	**0.004**	**0.007**	0.725
					12 lags				
Industrial production	**0.014**	0.085	0.076	**0.045**	0.177	0.311	**0.001**	**0.010**	**0.013**
Capacity utilization	**0.008**	**0.039**	0.098	**0.034**	0.254	0.503	**0.005**	**0.042**	**0.031**
Employment	0.126	0.122	**0.002**	**0.001**	**0.003**	**0.009**	**0.004**	**0.002**	**0.011**
Unemployment rate	**0.011**	0.181	0.242	0.162	0.210	0.236	0.616	0.641	0.722
Housing starts	**0.039**	**0.001**	**0.001**	**0.000**	**0.000**	**0.002**	**0.000**	**0.000**	**0.005**
Personal income per capita	0.058	0.419	0.188	0.330	0.546	0.366	**0.001**	**0.000**	**0.004**
Personal income	0.068	0.427	0.332	0.341	0.552	0.401	**0.002**	**0.000**	**0.005**
Consumption	0.784	0.231	**0.004**	**0.002**	**0.001**	**0.001**	**0.000**	**0.000**	**0.010**
Durable goods orders	0.074	0.078	**0.004**	**0.009**	**0.005**	**0.003**	**0.002**	**0.005**	0.064

	AIC optimal lags								
Industrial production	**0.001**	**0.005**	**0.000**	**0.000**	**0.007**	**0.010**	**0.000**	**0.000**	**0.000**
Capacity utilization	**0.001**	**0.003**	**0.001**	**0.001**	**0.019**	**0.042**	**0.000**	**0.002**	**0.001**
Employment	**0.027**	0.063	**0.001**	**0.001**	**0.001**	**0.003**	**0.000**	**0.000**	**0.007**
Unemployment rate	**0.002**	**0.026**	0.137	0.073	0.169	0.319	0.112	0.088	0.374
Housing starts	**0.008**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Personal income per capita	**0.034**	0.077	0.428	0.938	0.628	0.231	**0.001**	**0.000**	**0.004**
Personal income	**0.043**	0.065	0.552	0.882	0.598	0.257	**0.002**	**0.000**	**0.004**
Consumption	0.954	0.076	**0.006**	**0.004**	**0.001**	**0.001**	**0.000**	**0.000**	**0.008**
Durable goods orders	**0.044**	**0.010**	**0.000**	**0.001**	**0.000**	**0.000**	**0.001**	**0.001**	0.117

Notes: Sample period, monthly data: 1968:01–2018:03. Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

TABLE 5. Granger causality test results with log levels and controlling for the interest rate

Forecasted variable	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
	6 lags							
Industrial production	0.315	0.096	0.051	0.166	0.329	**0.003**	**0.007**	**0.035**
Capacity utilization	0.178	0.177	0.095	0.179	0.304	**0.015**	**0.026**	0.081
Employment	0.654	0.056	0.036	**0.042**	0.066	**0.007**	**0.004**	0.093
Unemployment rate	0.874	0.784	0.830	0.661	0.619	0.085	0.052	0.497
Housing starts	0.277	**0.018**	**0.011**	**0.005**	**0.009**	**0.000**	**0.000**	**0.004**
Personal income per capita	0.508	0.916	0.896	0.786	0.821	0.090	**0.027**	0.165
Personal income	0.595	**0.000**	0.961	0.901	0.937	0.194	0.093	0.298
Consumption	0.419	**0.007**	**0.006**	**0.002**	**0.002**	**0.000**	**0.000**	0.266
Durable goods orders	**0.035**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.027**
	12 lags							
Industrial production	0.693	0.556	0.476	0.689	0.836	0.057	0.052	0.105
Capacity utilization	0.418	0.782	0.692	0.734	0.830	0.196	0.202	0.227
Employment	0.419	**0.007**	**0.004**	**0.018**	**0.039**	**0.005**	**0.007**	**0.029**
Unemployment rate	0.597	0.422	0.453	0.450	0.443	0.563	0.491	0.853
Housing starts	0.687	0.172	0.089	0.056	0.115	**0.000**	**0.000**	**0.023**
Personal income per capita	0.746	0.883	0.925	0.816	0.747	0.320	0.098	0.470
Personal income	0.804	**0.000**	0.946	0.876	0.821	0.513	0.258	0.685
Consumption	0.610	**0.047**	**0.034**	**0.014**	**0.015**	**0.001**	**0.000**	0.236
Durable goods orders	0.108	**0.001**	**0.006**	**0.007**	**0.003**	**0.000**	**0.000**	0.075

	AIC optimal lags							
Industrial production	0.187	**0.026**	**0.013**	**0.029**	0.064	**0.001**	**0.001**	**0.004**
Capacity utilization	0.134	0.123	0.085	0.119	0.274	**0.016**	**0.024**	**0.016**
Employment	0.182	**0.008**	**0.001**	**0.005**	**0.020**	**0.001**	**0.001**	**0.029**
Unemployment rate	0.290	0.772	0.552	0.584	0.830	0.075	0.058	0.936
Housing starts	0.380	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Personal income per capita	0.140	0.323	0.174	0.108	0.264	**0.017**	**0.005**	0.065
Personal income	0.228	0.691	0.369	0.269	0.700	**0.022**	**0.010**	0.083
Consumption	0.278	**0.002**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	0.196
Durable goods orders	**0.013**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.018**

Notes: Sample period, monthly data: 1967:01–2018:03. Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

TABLE 6. Granger causality test results with monthly growth rates and controlling for the interest rate

Forecasted variable	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
	6 lags							
Industrial production	0.183	0.073	**0.024**	0.109	0.299	**0.003**	**0.004**	**0.009**
Capacity utilization	0.165	0.138	**0.018**	0.237	0.653	**0.015**	**0.026**	**0.024**
Employment	0.302	**0.011**	**0.008**	**0.010**	**0.026**	**0.005**	**0.003**	0.059
Unemployment rate	0.420	0.546	0.288	0.483	0.779	0.330	0.349	0.830
Housing starts	0.277	0.052	**0.013**	**0.012**	**0.046**	**0.002**	**0.010**	**0.044**
Personal income per capita	0.606	0.922	0.940	0.917	0.843	**0.100**	**0.041**	0.155
Personal income	0.586	0.923	0.933	0.850	0.837	0.096	**0.038**	0.146
Consumption	0.359	**0.011**	**0.015**	**0.002**	**0.002**	**0.000**	**0.000**	0.200
Durable goods orders	**0.015**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.045**
	12 lags							
Industrial production	0.421	0.610	0.479	0.509	0.698	**0.021**	**0.013**	**0.035**
Capacity utilization	0.429	0.764	0.475	0.700	0.905	0.056	**0.041**	0.083
Employment	0.266	**0.004**	**0.002**	**0.006**	**0.019**	**0.006**	**0.004**	**0.012**
Unemployment rate	0.269	0.338	0.236	0.357	0.500	0.653	0.644	0.949
Housing starts	0.600	0.179	0.056	**0.049**	0.168	**0.000**	**0.001**	**0.044**
Personal income per capita	0.858	0.894	0.940	0.905	0.816	0.407	0.176	0.512
Personal income	0.849	0.897	0.937	0.903	0.818	0.407	0.174	0.517
Consumption	0.561	0.093	**0.038**	**0.018**	**0.041**	**0.002**	**0.002**	0.343
Durable goods orders	0.077	**0.004**	**0.008**	**0.006**	**0.004**	**0.001**	**0.001**	0.097

	AIC optimal lags							
Industrial production	**0.043**	**0.010**	**0.001**	**0.003**	**0.019**	**0.001**	**0.001**	**0.002**
Capacity utilization	**0.034**	**0.017**	**0.001**	**0.007**	0.131	**0.005**	**0.015**	**0.006**
Employment	**0.036**	**0.001**	**0.000**	**0.001**	**0.005**	**0.001**	**0.002**	**0.015**
Unemployment rate	0.573	0.451	**0.044**	0.463	0.691	0.225	0.234	0.367
Housing starts	0.100	**0.011**	**0.001**	**0.001**	**0.011**	**0.000**	**0.000**	**0.019**
Personal income per capita	0.294	0.796	0.535	0.745	0.667	**0.007**	**0.001**	**0.018**
Personal income	0.280	0.769	0.515	0.763	0.658	**0.006**	**0.002**	**0.016**
Consumption	0.053	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.051
Durable goods orders	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.003**

Notes: Sample period, monthly data: 1967:02–2018:03. Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

TABLE 7. Granger causality test results with annual growth rates and controlling for the interest rate

Forecasted variable	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
	6 lags							
Industrial production	**0.013**	**0.001**	**0.000**	**0.001**	**0.003**	**0.000**	**0.000**	**0.001**
Capacity utilization	**0.008**	**0.001**	**0.000**	**0.002**	**0.008**	**0.000**	**0.002**	**0.003**
Employment	0.446	**0.013**	**0.003**	**0.004**	**0.023**	**0.002**	**0.001**	**0.043**
Unemployment rate	0.201	0.294	0.168	0.174	0.290	0.115	0.088	0.246
Housing starts	0.096	**0.002**	**0.000**	**0.000**	**0.001**	**0.000**	**0.000**	**0.002**
Personal income per capita	0.640	0.799	0.801	0.938	0.954	0.119	0.052	0.186
Personal income	0.623	0.796	0.812	0.416	0.955	0.125	0.054	0.187
Consumption	0.129	**0.010**	**0.003**	**0.001**	**0.003**	**0.000**	**0.000**	0.353
Durable goods orders	**0.031**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.241
	12 lags							
Industrial production	**0.039**	**0.020**	**0.011**	**0.038**	0.065	**0.002**	**0.014**	**0.021**
Capacity utilization	**0.021**	**0.028**	**0.009**	0.058	0.116	**0.005**	**0.044**	**0.047**
Employment	0.089	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unemployment rate	0.099	0.083	**0.029**	**0.048**	0.085	0.444	0.431	0.573
Housing starts	**0.019**	**0.009**	**0.000**	**0.001**	**0.008**	**0.000**	**0.000**	**0.007**
Personal income per capita	0.169	0.221	0.435	0.538	0.287	**0.004**	**0.000**	**0.006**
Personal income	0.160	0.438	0.459	0.567	0.353	**0.006**	**0.000**	**0.008**
Consumption	0.144	**0.002**	**0.001**	**0.000**	**0.001**	**0.000**	**0.000**	**0.020**
Durable goods orders	0.059	**0.001**	**0.002**	**0.002**	**0.001**	**0.000**	**0.001**	0.056

	AIC optimal lags							
Industrial production	**0.003**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Capacity utilization	**0.003**	**0.001**	**0.000**	**0.001**	**0.002**	**0.000**	**0.001**	**0.001**
Employment	**0.043**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unemployment rate	**0.011**	0.092	**0.017**	**0.023**	**0.038**	0.076	0.051	0.248
Housing starts	**0.004**	**0.002**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Personal income per capita	0.080	0.235	0.892	0.292	0.052	**0.001**	**0.000**	**0.002**
Personal income	0.060	0.404	0.949	0.343	0.088	**0.002**	**0.000**	**0.005**
Consumption	0.076	**0.004**	**0.002**	**0.000**	**0.001**	**0.000**	**0.000**	**0.008**
Durable goods orders	**0.002**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.004**

Notes: Sample period, monthly data: 1968:01–2018:03. Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

and present the results in Tables 8 and 9, respectively. We do so only for the optimal lag structure (chosen by the AIC), and in panel A of each table we show the results using log levels, in panel B the results using monthly growth rates, and in panel C the results using annualized growth rates. As can be seen in Table 8, our earlier conclusions regarding the superiority of the broad Divisia money measures over the narrow Divisia money measures hold. Moreover, as can be seen in Table 9, all broad Divisia money measures are more informative relative to the federal funds rate, and our earlier conclusion that Divisia money can be preferred to the federal funds rate as an indicator or intermediate target in the conduct of monetary policy also holds.

Following Belongia and Ireland (2015), we further restrict our sample to 2000–2018 being the period leading up to and the aftermath of the global financial crisis and recession of 2007–2008. We reestimate both our baseline causality equation (1) as well as the alternative equation (2) in which we control for the interest rate. These additional results are reported in the Online Appendix Tables A2 and A3 with the data in log levels, monthly growth rates, and annual growth rates. In these tables, we only report the results based on the AIC optimal lag length specifications. Like Belongia and Ireland (2015), for this sample period, we find that the narrow money measures outperform the federal funds rate in terms of their ability to predict real economic activity. However, there is no conclusive evidence regarding the superiority of the broad Divisia monetary aggregates over the narrow ones over this sample period.

Finally, it should be noted that we have used p-values based on the usual F-distribution assuming asymptotic normality. However, we also investigate the robustness of our results to the use of p-values based on the nonstandard asymptotic distribution, computed as described in Appendix B of Stock and Watson (1989); it has been argued that the latter is more appropriate when using the variables in levels. Generally, all the conclusions based on the usual F-distribution still hold if we use the bootstrap Granger causality test. In particular, the superiority of the broad Divisia money measures over the narrow ones and the federal funds rate in predicting real economic activities still holds. We provide the normal and bootstrap Granger causality test results in the Online Appendix Table A4.

5. A STRUCTURAL VAR MODEL OF MONETARY POLICY

The cyclical correlations and reduced form analysis clearly indicate that broad Divisia money measures are more informative in predicting real economic activities than narrow Divisia money measures. In order to provide a more coherent treatment, in this section, we introduce a six-variable (identified) structural VAR similar to the one used by Leeper and Roush (2003) and Belongia and Ireland (2015). However, our econometric modeling is significantly different as we implement the structural VAR with a GARCH error structure. In what follows, we briefly describe the model.

TABLE 8. Granger causality test results with AIC optimal lags and restricted sample (1980:01–2018:03)

Forecasted variable	Fed funds rate	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
	A: Logged levels								
Industrial production	**0.010**	0.219	0.562	0.250	0.221	0.542	0.211	0.641	**0.020**
Capacity utilization	**0.005**	0.258	0.523	0.714	0.204	0.159	0.149	0.156	**0.012**
Employment	**0.002**	**0.020**	0.388	**0.027**	0.222	0.698	0.142	0.052	0.148
Unemployment rate	**0.003**	0.074	**0.002**	**0.004**	**0.002**	**0.000**	0.098	0.166	0.165
Housing starts	**0.002**	0.151	0.100	**0.018**	**0.022**	0.087	**0.003**	**0.013**	0.094
Personal income per capita	0.506	0.351	0.874	0.638	0.593	0.919	**0.010**	**0.004**	**0.026**
Personal income	0.378	0.502	0.720	0.963	0.965	0.580	**0.012**	**0.007**	**0.018**
Consumption	0.516	0.084	0.195	0.127	0.135	0.236	0.087	0.079	0.931
Durable goods orders	**0.027**	**0.002**	0.165	**0.008**	**0.013**	0.089	**0.018**	**0.016**	0.936
	B: Monthly growth rates								
Industrial production	**0.008**	**0.031**	0.697	0.074	0.089	0.165	0.051	0.061	**0.014**
Capacity utilization	**0.019**	**0.037**	0.632	0.123	0.114	0.085	0.058	0.052	**0.008**
Employment	**0.003**	0.095	0.693	**0.015**	0.797	0.881	0.087	0.077	0.104
Unemployment rate	**0.002**	**0.002**	**0.001**	**0.000**	**0.000**	**0.000**	**0.018**	**0.039**	**0.037**
Housing starts	**0.002**	**0.023**	0.052	**0.008**	**0.015**	0.067	**0.005**	**0.028**	0.521
Personal income per capita	0.245	0.412	0.372	0.353	0.506	0.765	**0.006**	**0.002**	**0.017**
Personal income	0.548	0.622	0.583	0.351	0.822	0.818	**0.005**	**0.002**	**0.014**
Consumption	0.629	0.484	0.547	0.194	**0.033**	0.189	**0.011**	**0.009**	0.535
Durable goods orders	0.088	**0.015**	0.091	**0.042**	**0.027**	0.060	**0.028**	**0.021**	0.727

TABLE 8. Continued

Forecasted variable	C: Annual growth rates								
	Fed funds rate	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
Industrial production	**0.005**	**0.008**	**0.013**	**0.010**	**0.033**	**0.829**	**0.000**	**0.011**	**0.000**
Capacity utilization	**0.001**	**0.002**	**0.016**	**0.005**	**0.027**	**0.591**	**0.000**	**0.008**	**0.000**
Employment	**0.043**	0.134	**0.040**	**0.011**	**0.004**	**0.012**	0.059	**0.046**	**0.013**
Unemployment rate	**0.000**	**0.001**	**0.000**	**0.001**	**0.000**	**0.000**	**0.035**	**0.042**	**0.016**
Housing starts	**0.000**	**0.001**	0.122	0.066	0.069	0.090	**0.004**	**0.007**	**0.048**
Personal income per capita	**0.003**	0.133	0.904	0.322	0.374	0.722	**0.001**	**0.000**	**0.004**
Personal income	**0.004**	0.127	0.772	0.333	0.250	0.706	**0.001**	**0.000**	**0.004**
Consumption	0.303	0.124	0.475	0.246	0.125	**0.039**	0.098	**0.038**	**0.019**
Durable goods orders	0.131	**0.215**	0.294	0.267	0.135	0.141	0.085	0.221	0.450

Notes: Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

TABLE 9. Granger causality test results with AIC optimal lags for restricted sample (1980:01-2018:03) and controlling for the interest rate

Forecasted variable	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
	A: Logged levels							
Industrial production	0.103	0.439	0.183	0.745	0.519	0.677	0.769	0.101
Capacity utilization	0.098	0.149	0.215	0.110	0.065	0.091	0.097	**0.029**
Employment	0.054	0.342	**0.013**	0.244	0.197	**0.016**	**0.015**	**0.045**
Unemployment rate	0.182	**0.002**	**0.002**	**0.003**	**0.001**	0.123	0.201	0.137
Housing starts	0.131	0.089	**0.001**	**0.001**	**0.005**	**0.001**	**0.001**	0.057
Personal income per capita	0.162	0.434	0.244	0.194	0.446	**0.010**	**0.005**	**0.042**
Personal income	0.232	0.776	0.427	0.392	0.938	**0.016**	**0.010**	**0.023**
Consumption	0.103	0.235	0.131	0.133	0.291	**0.000**	**0.000**	0.844
Durable goods orders	**0.005**	**0.018**	**0.003**	**0.001**	**0.006**	**0.001**	**0.002**	0.806
	B: Monthly growth rates							
Industrial production	**0.022**	0.926	0.065	**0.048**	0.500	0.052	0.059	**0.039**
Capacity utilization	**0.023**	0.735	**0.012**	0.145	0.192	0.734	0.074	**0.021**
Employment	**0.036**	0.199	**0.011**	0.121	0.222	**0.014**	**0.011**	0.085
Unemployment rate	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.012**	**0.031**	**0.031**
Housing starts	**0.014**	0.052	**0.008**	**0.013**	0.097	**0.008**	0.055	0.568
Personal income per capita	0.429	0.422	0.391	0.614	0.996	**0.006**	**0.002**	**0.011**
Personal income	0.634	0.399	0.384	0.921	0.933	**0.006**	**0.002**	**0.010**
Consumption	0.494	0.584	0.212	**0.010**	0.114	**0.012**	**0.009**	0.528
Durable goods orders	**0.003**	**0.025**	**0.008**	**0.003**	**0.011**	**0.011**	**0.009**	0.613

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TABLE 9. Continued

	C: Annual growth rates							
Forecasted variable	Divisia M1	Divisia M2	Divisia M2M	Divisia MZM	Divisia ALL	Divisia M3	Divisia M4-	Divisia M4
Industrial production	**0.008**	**0.001**	**0.000**	**0.002**	**0.006**	**0.000**	**0.020**	**0.000**
Capacity utilization	**0.002**	**0.001**	**0.000**	**0.003**	**0.002**	**0.000**	**0.023**	**0.001**
Employment	**0.032**	**0.008**	**0.001**	**0.000**	**0.001**	**0.004**	**0.002**	**0.001**
Unemployment rate	**0.000**	**0.002**	**0.003**	**0.000**	**0.000**	**0.009**	**0.012**	**0.004**
Housing starts	**0.001**	**0.030**	**0.004**	**0.032**	**0.027**	**0.007**	**0.007**	0.120
Personal income per capita	0.205	0.534	0.913	0.283	0.107	**0.001**	**0.000**	**0.002**
Personal income	0.176	0.761	1.000	0.272	0.139	**0.001**	**0.000**	**0.002**
Consumption	0.495	0.771	0.310	0.157	**0.045**	0.110	**0.041**	**0.012**
Durable goods orders	0.065	0.123	0.094	0.098	0.100	**0.021**	0.116	0.623

Notes: Numbers are marginal significance levels. Bold numbers indicate significance at the 5% level.

Let M_t denote a Divisia monetary aggregate and UC_t its corresponding user cost. Also let Y_t, P_t, and R_t denote industrial production, the price level, and the federal funds rate, respectively. Following convention in the literature, we include the CRB/BLS spot commodity price index, CP_t, to mitigate the price puzzle. All variables are in log levels and scaled by 100 except for the interest rate and the user cost of money which are in levels. Thus, in what follows a lowercase letter indicates the logarithm of the corresponding uppercase letter.

Let z_t be a stacked 6×1 vector of the relevant variables

$$z_t = [p_t \; y_t \; cp_t \; R_t \; m_t \; UC_t]',$$

and define the structural VAR model as

$$\boldsymbol{B} z_t = \boldsymbol{\Gamma}_0 + \sum_{k=1}^{p} \boldsymbol{\Gamma}_k z_{t-k} + \varepsilon_t, \tag{3}$$

where $\boldsymbol{B}$ is a 6×6 matrix of contemporaneous coefficients with ones on the principal diagonal, $\boldsymbol{\Gamma}_0$ is a 6×1 vector of constants, $\boldsymbol{\Gamma}_k$, $k = 1, ..., p$ is a 6×6 matrix of coefficients, and finally ε_t is a 6×1 vector of structural disturbances such that $E[\varepsilon_t] = 0$, $E\left[\varepsilon_t \varepsilon_t'\right] = \boldsymbol{H}_t$ and $E\left[\varepsilon_t \varepsilon_s'\right] = 0, \forall\, t \neq s$. The vector of structural disturbances, ε_t, is modeled as a GARCH (1,1) process with the conditional variances given by the diagonal element of $\boldsymbol{H}_t$. Thus, we use this GARCH (1,1) process to model the evolution of $\boldsymbol{H}_t$ over time

$$h_{it} = \delta_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}, \quad i = 1, ..., 6. \tag{4}$$

The reduced form version of (3) is given by

$$z_t = \boldsymbol{A}_0 + \sum_{k=1}^{p} \boldsymbol{A}_k z_{t-k} + \boldsymbol{e}_t,$$

where $\boldsymbol{A}_0 = \boldsymbol{B}^{-1}\Gamma_0$, $\boldsymbol{A}_k = \boldsymbol{B}^{-1}\Gamma_k$, $\boldsymbol{e}_t = \boldsymbol{B}^{-1}\varepsilon_t$ and $\boldsymbol{e}_t = [e_t^p \; e_t^y \; e_t^{cp} \; e_t^R \; e_t^m \; e_t^{UC}]'$ is the vector of zero-mean reduced form disturbances such that $E\left[\boldsymbol{e}_t \boldsymbol{e}_t'\right] = \Sigma_t$. Thus, the structural disturbances are connected to the reduced form innovations through

$$\boldsymbol{e}_t = \boldsymbol{B}^{-1}\varepsilon_t.$$

The reduced form innovations are time-varying, that is,

$$E\left[\boldsymbol{e}_t \boldsymbol{e}_t'\right] = E\left[\boldsymbol{B}^{-1}\varepsilon_t\varepsilon_t'\left(\boldsymbol{B}^{-1}\right)'\right] = \boldsymbol{B}^{-1}E\left[\varepsilon_t\varepsilon_t'\right]\left(\boldsymbol{B}^{-1}\right)' = \boldsymbol{B}^{-1}\boldsymbol{H}_t\left(\boldsymbol{B}^{-1}\right)' = \boldsymbol{S}_t\boldsymbol{S}_t' = \boldsymbol{V}_t,$$

where $\boldsymbol{S}_t = \boldsymbol{B}^{-1}\boldsymbol{H}_t^{1/2}$. Provided that the $\boldsymbol{B}$ and consequently $\boldsymbol{S}$ matrices are not diagonal, then $\boldsymbol{V}_t$ is also not diagonal, and the volatility of each variable has an effect on all the variables in the VAR—see Martin *et al*. (2013) for more details.

To estimate the parameters of interest, we use an identification scheme similar to that of Belongia and Ireland (2016) restricting the $\boldsymbol{B}$ matrix as follows:

$$\boldsymbol{B} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & b_{34} & b_{35} & b_{36} \\ b_{41} & b_{42} & 0 & 1 & b_{45} & 0 \\ -1 & b_{52} & 0 & b_{54} & 1 & b_{56} \\ -b_{65} & b_{62} & 0 & b_{64} & b_{65} & 1 \end{bmatrix}.$$

This non-recursive identification strategy provides a more tightly and theoretically motivated specification that allows money to play a role in the conduct of monetary policy. It also allows us to distinguish between money demand and money supply shocks. Leeper and Roush (2003) used a similar identification strategy with the simple-sum M2 monetary aggregate in their specification of the monetary policy rule. Belongia and Ireland (2016) extend the Leeper and Roush (2003) work, using the same identification strategy but with the narrow Divisia monetary aggregates—Divisia M1, Divisia M2, Divisia MZM, and Divisia ALL—instead of the simple-sum aggregates. In this paper, we build on Belongia and Ireland (2016) by providing a comparison between the narrow Divisia monetary aggregates at the M1, M2, M2M, MZM, and ALL levels of aggregation and the broad Divisia monetary aggregates—Divisia M4, Divisia M4-, and Divisia M3.

The first two rows of the $\boldsymbol{B}$ matrix imply that the price level and output respond to policy disturbances with a lag of one period. Given the monthly frequency of our data, this timing restriction is obviously benign. In this identification scheme, the commodity prices variable is an information variable, responding to every shock in the economy. The fourth row of the $\boldsymbol{B}$ matrix can be described as a generalized Taylor (1993) rule in which the supply of monetary services (as opposed to commodity prices) enter as an additional variable. This rule requires the central bank to adjust its policy rate in response to changes in the supply of money as well as changes in the general level of prices and aggregate output. An alternative interpretation of the fourth row, given by Belongia and Ireland (2015), is that the central bank's policy actions simultaneously affect both the interest rate and the money supply. It is worth noticing that the idea of associating MPS with simultaneous movements in the interest rate and the money supply was first proposed by Sims (1986), and used by Leeper and Roush (2003) and Belongia and Ireland (2016). Thus, our identified MPS is given by

$$b_{41}p_t + b_{42}y_t + R_t + b_{45}m_t = \varepsilon_t^{MPS}. \tag{5}$$

The fifth row of $\boldsymbol{B}$ gives the real money demand equation associating real money balances, $m_t - p_t$, with output, y_t, and the user cost of money, UC_t. As already noted, the user cost of money is the opportunity cost price of the services provided by money. The user cost of money should capture the price of money more appropriately than the traditional interest rate which is the price of a money substitute (bonds). Hence, in our money demand equation below, we use the user

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cost of money to capture the price of money but still control for the price of a money substitute

$$b_{52}y_t + b_{54}R_t + (m_t - p_t) + b_{56}UC_t = \varepsilon_t^{MDS}. \quad (6)$$

The last row of $\boldsymbol{B}$ describes an equation for capturing shocks to the monetary system which creates liquid assets. Households and firms are provided with monetary services from these liquid assets. The institutions which create these assets include the central bank itself and private financial institutions. The degree of liquidity is modeled to depend on the level of output, real money balances, and the interest rate

$$b_{62}y_t + b_{64}R_t + b_{65}(m_t - p_t) + UC_t = \varepsilon_t^{MSS}. \quad (7)$$

Our model is based on this specification, but to ensure the robustness of our results to other common specifications, we first estimate the model under a homoskedastic error structure and test for Autoregressive conditional heteroskedasticity (ARCH)-type effects in the VAR residuals. In Online Appendix Figures A2 and A3, we present the residuals from the homoskedastic model under a narrow and a broad Divisia money measure, Divisia M2 and Divisia M4, respectively. These graphs clearly indicate that the variance of the VAR residuals is not constant over time. In Online Appendix Table A5, we also report the results of Lagrange multiplier tests for ARCH effects. As can be seen, the null hypothesis of no ARCH in each of the VAR residuals is rejected with p-values less than 0.001. We, therefore, estimate the multivariate VAR assuming the GARCH(1,1) specification in equation (4) for the error structure. An added advantage of doing so is that identification problems may be alleviated, as noted by Sentana and Fiorentini (2001). Moreover, we are able to present time-varying forecast error variance decompositions for the relevant variables. This is important since it allows us to track the changes in the importance of the different shocks in explaining the variations in real output and prices for any year within the sample period and at different forecast horizons.

6. EMPIRICAL EVIDENCE

6.1. Impulse Response Functions

As already mentioned, we want to assess the dynamic effects of MPS in the context of a monetary policy rule where the Fed's policy actions simultaneously affect both the interest rate and the money supply. We search for relationships over five narrow Divisia definitions of the money supply—M1, M2, M2M, MZM, and ALL—and three broad Divisia definitions of the money supply—M3, M4-, and M4—in an attempt to deal with problems that arise because of different definitions of money. The model is estimated by full information maximum likelihood, simultaneously estimating the mean and variance equations and avoiding Pagan's (1984) generated regressor problems. This involves maximization of the log-likelihood function with respect to the structural parameters.

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TABLE 10. Parameter estimates of the SVAR-GARCH with money defined by Divisia M4

A. Conditional mean equation

$$\mathbf{B} = \begin{bmatrix} 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ -0.0311\ (0.825) & 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 2.6093\ (0.000) & 0.4184\ (0.003) & 1.0000 & 0.5372\ (0.009) & 0.3516\ (0.111) & -2.7277\ (0.400) \\ 0.0818\ (0.182) & 0.0728\ (0.000) & 0.0000 & 1.0000 & -0.0052\ (0.895) & 0.0000 \\ -1.0000 & 0.0487\ (0.095) & 0.000 & -0.0892\ (0.085) & 1.0000 & 2.6697\ (0.023) \\ -0.0001\ (0.974) & 0.0019\ (0.097) & 0.0000 & 0.0196\ (0.000) & 0.0001\ (0.974) & 1.0000 \end{bmatrix}$$

B. Conditional variance equation

$$\delta = \begin{bmatrix} 0.0163\ (0.000) \\ 0.1844\ (0.002) \\ 0.3489\ (0.172) \\ 0.0083\ (0.000) \\ 0.0177\ (0.019) \\ 0.0001\ (0.003) \end{bmatrix}; \alpha = \begin{bmatrix} 0.1993\ (0.000) \\ 0.0914\ (0.002) \\ 0.0585\ (0.023) \\ 0.2379\ (0.000) \\ 0.1287\ (0.001) \\ 0.2603\ (0.000) \end{bmatrix}; \beta = \begin{bmatrix} 0.3149\ (0.001) \\ 0.3151\ (0.117) \\ 0.8502\ (0.000) \\ 0.7073\ (0.000) \\ 0.7462\ (0.000) \\ 0.5217\ (0.000) \end{bmatrix}$$

Note: Numbers in parentheses are p-values.

TABLE 11. Parameter estimates of the SVAR-GARCH with money defined by Divisia M2

A. Conditional mean equation

$$\mathbf{B} = \begin{bmatrix} 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ -0.0561\ (0.678) & 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 2.6271\ (0.000) & 0.3215\ (0.022) & 1.0000 & 0.5264\ (0.016) & 0.1021\ (0.704) & -0.6305\ (0.874) \\ 0.0318\ (0.613) & 0.0648\ (0.001) & 0.0000 & 1.0000 & 0.0762\ (0.149) & 0.0000 \\ -1.0000 & 0.0407\ (0.149) & 0.0000 & -0.1540\ (0.004) & 1.00000 & 3.3881\ (0.002) \\ 0.0029\ (0.395) & -0.0038\ (0.000) & 0.0000 & 0.0227\ (0.000) & -0.0029\ (0.395) & 1.0000 \end{bmatrix}$$

B. Conditional variance equation

$$\delta = \begin{bmatrix} 0.0107\ (0.001) \\ 0.1860\ (0.000) \\ 0.4695\ (0.125) \\ 0.0081\ (0.000) \\ 0.0645\ (0.003) \\ 0.0001\ (0.001) \end{bmatrix}; \alpha = \begin{bmatrix} 0.1733\ (0.000) \\ 0.1051\ (0.002) \\ 0.0511\ (0.038) \\ 0.2594\ (0.000) \\ 0.1176\ (0.010) \\ 0.273\ (0.000) \end{bmatrix}; \beta = \begin{bmatrix} 0.5235\ (0.000) \\ 0.3024\ (0.001) \\ 0.8279\ (0.000) \\ 0.6976\ (0.000) \\ 0.2270\ (0.332) \\ 0.4220\ (0.000) \end{bmatrix}$$

Note: Numbers in parentheses are p-values.

In Tables 10 and 11, we report point estimates of the ***B*** matrix as well as the GARCH (1,1) specification estimates for Divisia M4 (in Table 10) and Divisia M2 (in Table 11). The fourth to the sixth rows of the estimated ***B*** matrix show our estimates of the parameters in equations (5)–(7). We interpret our monetary

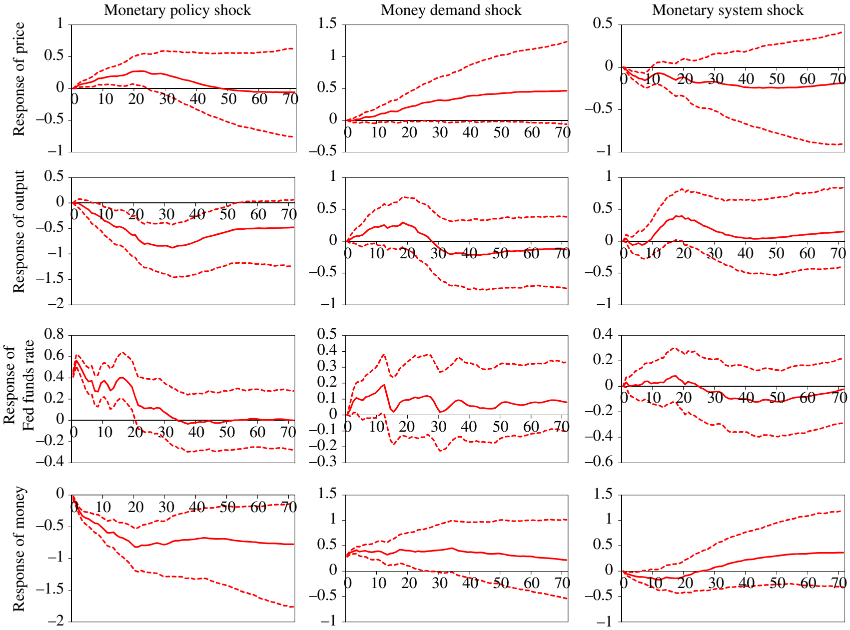

FIGURE 7. Impulse responses to shocks with money defined by Divisia M2

policy rule to be one in which a contractionary policy shock is associated with a simultaneous increase in the federal funds rate and a downward movement in the money supply; this pattern is reflected in the negative coefficient on Divisia M4 in the fourth row of Table 10, but not in the positive coefficient on Divisia M2 in the same row of Table 11. With regard to money demand, both the Divisia M4 and Divisia M2 estimates have the expected signs. We also expect the user cost of money (the price of money) to have a positive relationship with the interest rate (the price of a money substitute) and output and the user cost to be positively related. Comparing the sixth row of Table 10 to that of Table 11 shows that Divisia M4 satisfies all these expectations while Divisia M2 does not. The GARCH parameters are all positive as expected and mostly significant.

The impulse responses are generated from simulation of the maximum likelihood estimates of the model parameters, and the 95% confidence intervals are generated by simulation using the Monte Carlo method described in RATS with 2000 draws from the posterior distribution of the VAR coefficients and the covariance matrix of the innovations. For brevity, in Figures 7 and 8, we present impulse responses only for Divisia M2 and Divisia M4 (the unreported results for the other Divisia monetary aggregates are available upon request). The responses show the dynamic effects of the shock, over an expanse of 6 years, for each variable in the VAR. Dashed lines denote 95% confidence intervals.

In column 1 of Figure 7, we present impulse responses of the price level, output, federal funds rate, and money supply to a contractionary monetary policy

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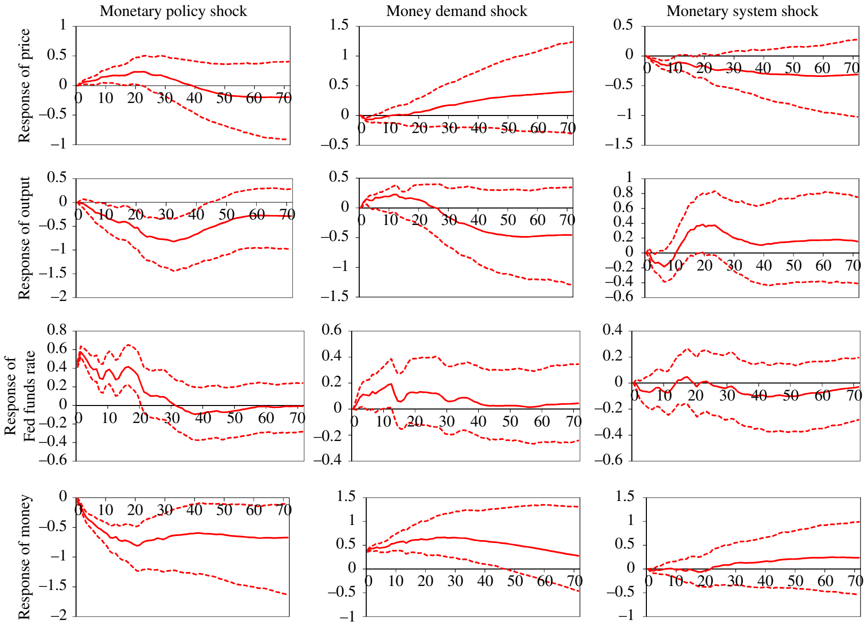

FIGURE 8. Impulse responses to shocks with money defined by Divisia M4

when the Divisia M2 aggregate is used in the monetary policy rule. Consistent with macroeconomic theory, we observe a statistically significant and persistent decline in the money supply, as well as a significant reduction in output, which bottoms out at negative 0.8% after a period of more than 2 years. After about 4 years, the decline in output becomes imprecisely estimated. In this regard, it should be noted that since the seminal work of Sims (1980b), a large number of authors report that contractionary MPS induce significant contractions in output. See, for example, Sims (1992), Leeper *et al.* (1996), Bagliano and Favero (1998), Christiano *et al.* (1999), Kim (1999), Belongia and Ireland (2015, 2016, 2018), and Arias *et al.* (2019). A notable exception to this general consensus is Uhlig (2005).

The tightness of the policy is reflected in the statistical significant increase in the federal funds rate, which slowly decays to zero after almost 2 years. The response of the price level to this contractionary MPS shows a price puzzle—the increase in the federal funds rate (i.e., contractionary monetary policy) produces increases, rather than decreases, in prices. However, the inflationary tendency is only precisely estimated for a period of less than 2 years after which the effect is possibly zero. Nonetheless, the existence of a price puzzle is surprising, since the literature has suggested that controlling for commodity prices tends to ameliorate the price puzzle. The impulse responses when the Divisia M4 aggregate is used are shown in column 1 of Figure 8 and are similar to those in column 1 of Figure 7 with Divisia M2. Particularly, it is worth noticing that for both Divisia

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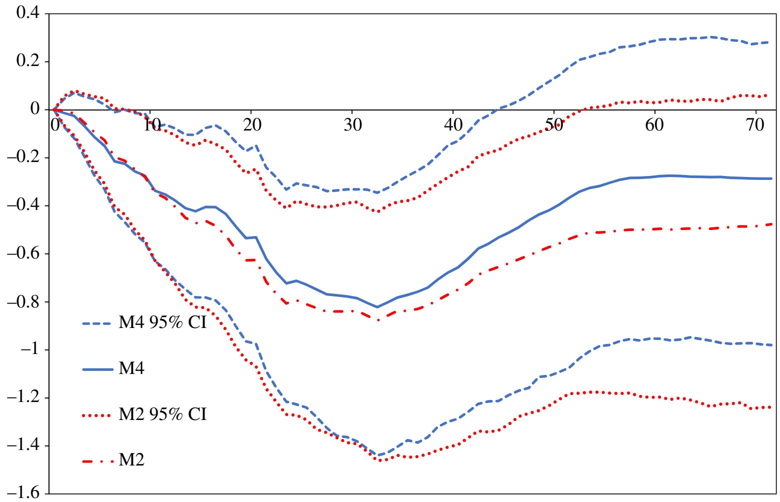

FIGURE 9. Output responses to a MPS with Divisia M2 and M4

M2 and Divisia M4, the decline in the money supply following a contractionary MPS remains significantly different from zero over an expanse of 72 months. Columns 2 and 3 of Figures 7 and 8 show the responses of the selected variables to MDS (in column 2) and MSS (in column 3). These responses are largely consistent with theoretical predictions regarding the impact of MDS and MSS.

In Figure 9 and 10, we present the impulse responses of output and prices, respectively, to contractionary monetary policy with the Divisia M2 and Divisia M4 monetary aggregates in the policy rule. In these figures, we superimpose the 95% confidence interval of each impulse response to highlight the overlap in the range of responses. As shown in both figures, there is significant overlap in the responses of output and prices to contractionary MPS with the Divisia M2 and Divisia M4 monetary aggregates, but there also some difference in the range of responses.

To simplify the comparison of the impulse responses of the variables of interest, output and the price level, to the identified contractionary MPS, in Figures 11 and 12, we plot the responses of output and the price level, respectively, to this shock for alternative Divisia definitions of money (M1, M2, M2M, MZM, ALL, M3, M4-, and M4). This allows us to see at a glance which Divisia money measure together with the interest rate shock will cause output to react more intensely to the shock. As shown in Figure 11, the decrease in output associated with a contractionary MPS is amplified with narrow definitions of the money supply. The divergence in the dynamic responses is obvious after the 10th month and becomes more pronounced with time. Figure 12 presents the impulse responses of the price level to a contractionary MPS again under alternative definitions of Divisia money. As can be seen, the contractionary monetary policy is associated with a less pronounced price puzzle (and possibly deflationary episode) when

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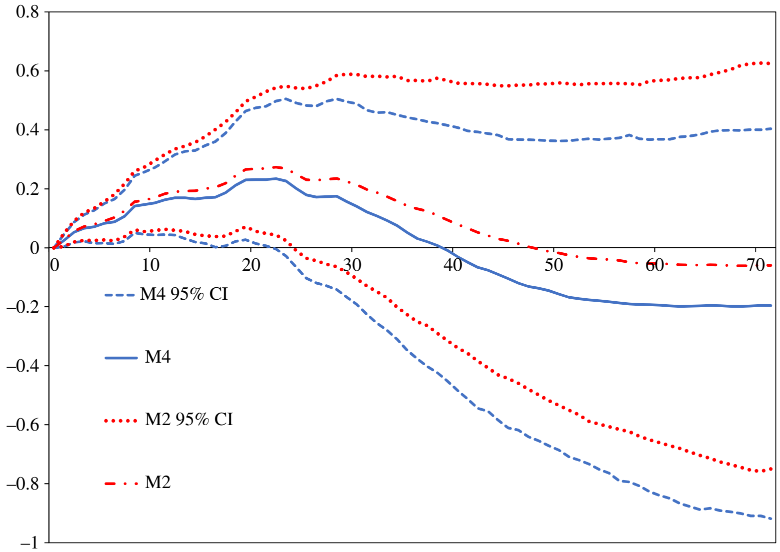

FIGURE 10. Price response to a MPS with Divisia M2 and M4

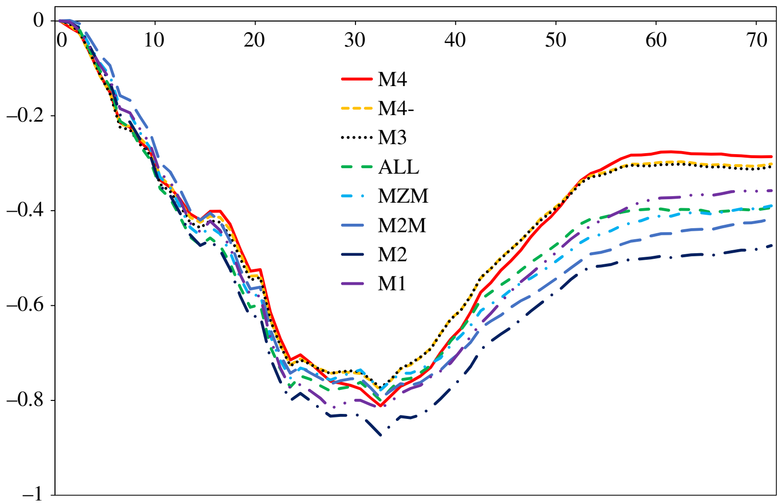

FIGURE 11. Output responses to a MPS under different definitions of Divisia money

money is defined broadly (M4, M4-, or M3) than when it is defined narrowly (ALL, MZM, M2M, M2, or M1). This point is also highlighted in Figure 10 which shows the confidence intervals for Divisia M4 and Divisia M2.

Our general conclusion that broad money is a better channel of monetary policy transmission than narrow money is supportive of the findings by Keating *et al.* (2019) who adduce a plethora of reasons for using M4 instead of M1 and M2

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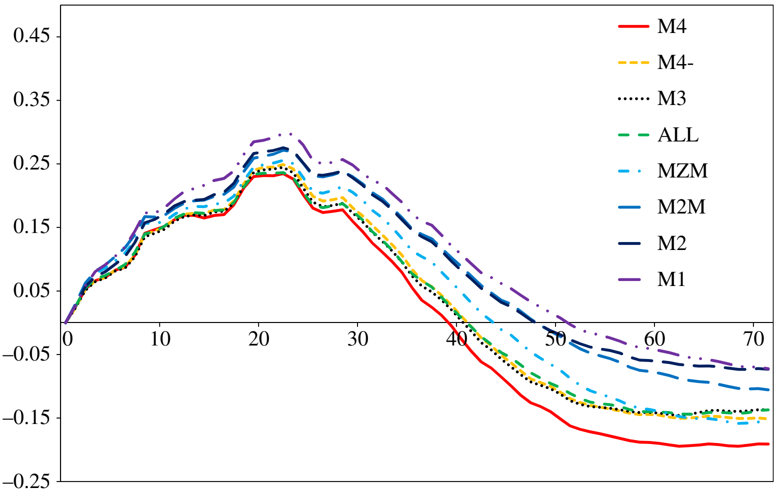

FIGURE 12. Price responses to a MPS under different definitions of Divisia money

as the substantive monetary policy variable. It is also consistent with Barnett's (2016, p. 282) conclusion that "we have nothing to lose using the highest level aggregate among those that are in the admissible hierarchy," and more recently with Jadidzadeh and Serletis (2019, p. 949) that "the CFS Divisia M4 monetary aggregate is the broadest and most theoretically consistent measure of money in the United States today."

6.2. Variance Decompositions

In Figures 13 and 14, we present the output forecast error variance decompositions showing the proportion of the variation of output that is explained by output (Y) shock, MPS, MDS, and MSS at each of 12, 48, and 72 steps for Divisia M2 and Divisia M4, respectively (the unreported results for the other Divisia money measures are available upon request). By allowing the errors to be heteroskedastic, following a GARCH (1,1) process, we are able to present time-varying forecast error variance decompositions for each shock of interest at different forecast horizons and at every point in the sample.

Focusing on Figure 14 when the Divisia M4 aggregate is used, it is obvious that the importance of output shocks in explaining the variation in output declines as we move from 12 to 48 to 72 steps ahead. At the same time, we see increasing significance of MPS in explaining the variations in output. In particular, with the exception of the 1980 to 1983 period, at 12 steps, output shocks explain more than 95% of the variation in output while MPS typically explain less than 5%. However, at 72 steps, MPS are slightly more important than output shocks. Our output forecast error variance decomposition also attributes variation in output over the 1980 to 1983 period to MPS, as the importance of output, MDS, and

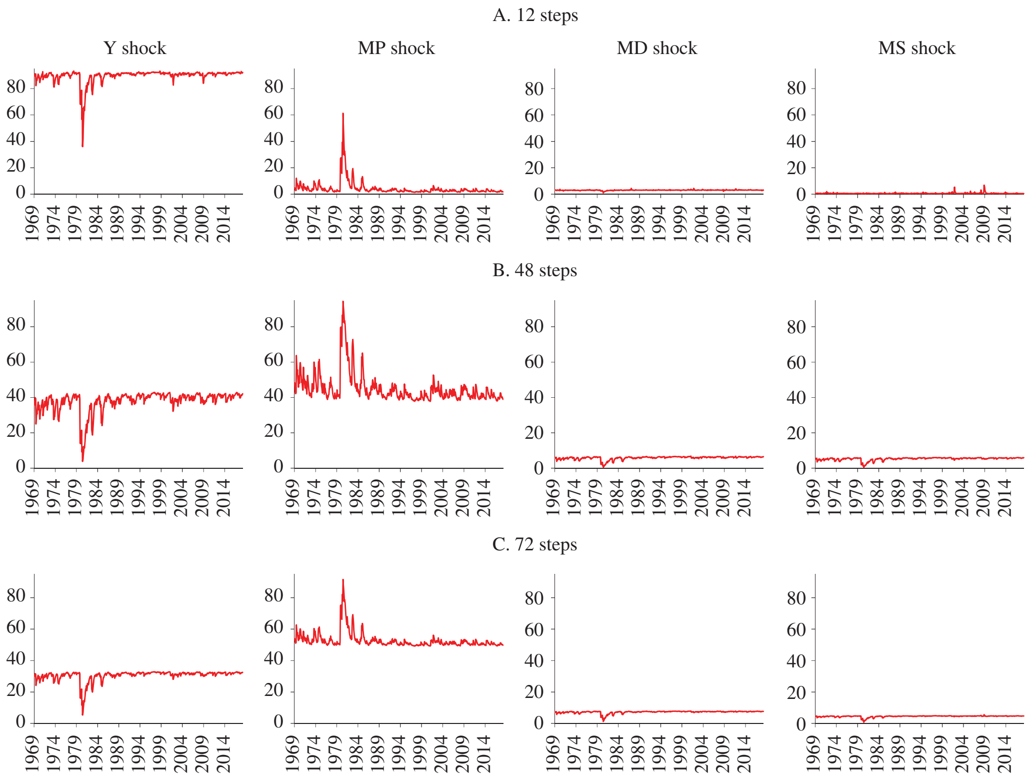

FIGURE 13. Output variance decompositions with Divisia M2

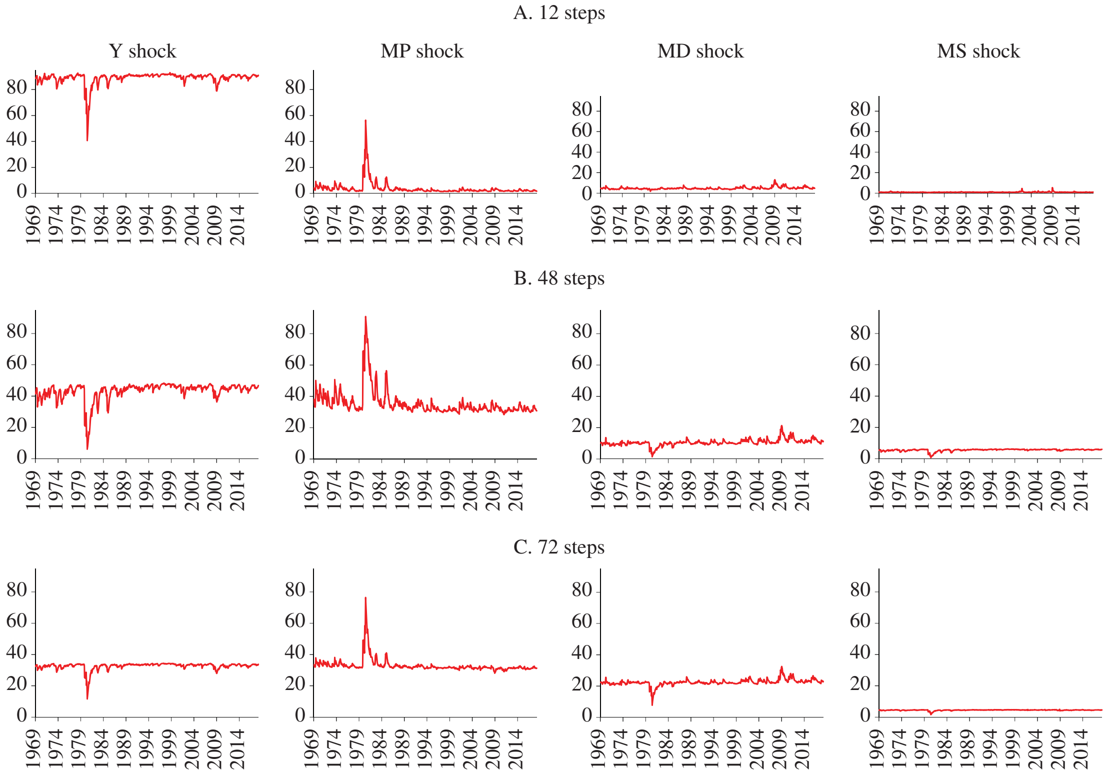

FIGURE 14. Output variance decompositions with Divisia M4

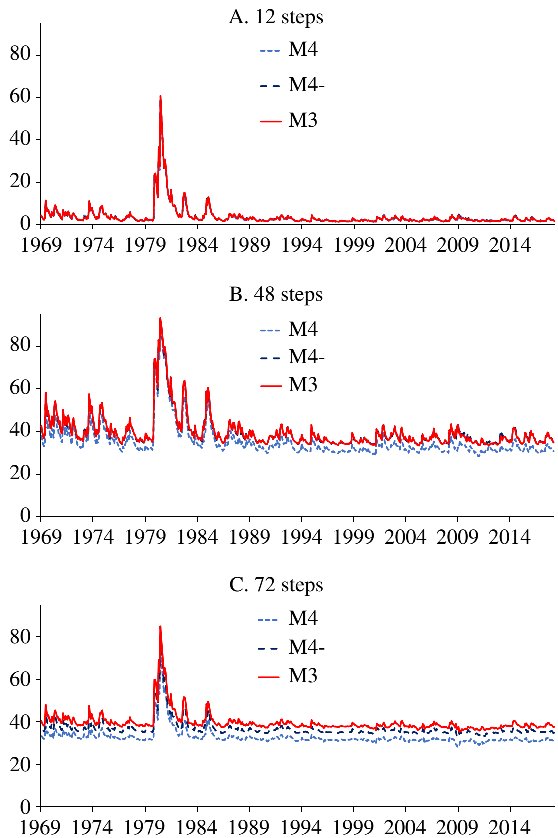

FIGURE 15. Proportion of ouput variance explained by MPS with broad Divisia money

MSS declines significantly during this period. Figure 14 also shows that MPS are relatively more important in explaining variations in output than MDS and MSS over the whole sample period. We make similar observations in terms of Figure 13 where we present output forecast error variance decompositions for the same shocks, but with money defined by Divisia M2. In general, our findings support those of Faust (1998) and Christiano *et al.* (2005) that MPS explain a nontrivial fraction of variation in real activities and particularly output.

To clearly identify which of the broad Divisia money measures enables MPS to explain a larger fraction of variation in output, in Figure 15, we present the proportion of output variance explained by MPS under different definitions of broad Divisia money in equation (5). It is clear that at 12 steps ahead, using any of the Divisia M4, Divisia M4-, or Divisia M3 aggregates, does not make any significant difference in the proportion of output variance explained by the MPS. However, at 72 steps, it is obvious that MPS explain between 30 and 45% of variations in output depending on which broad Divisia money measure (M4, M4-, or M3) is

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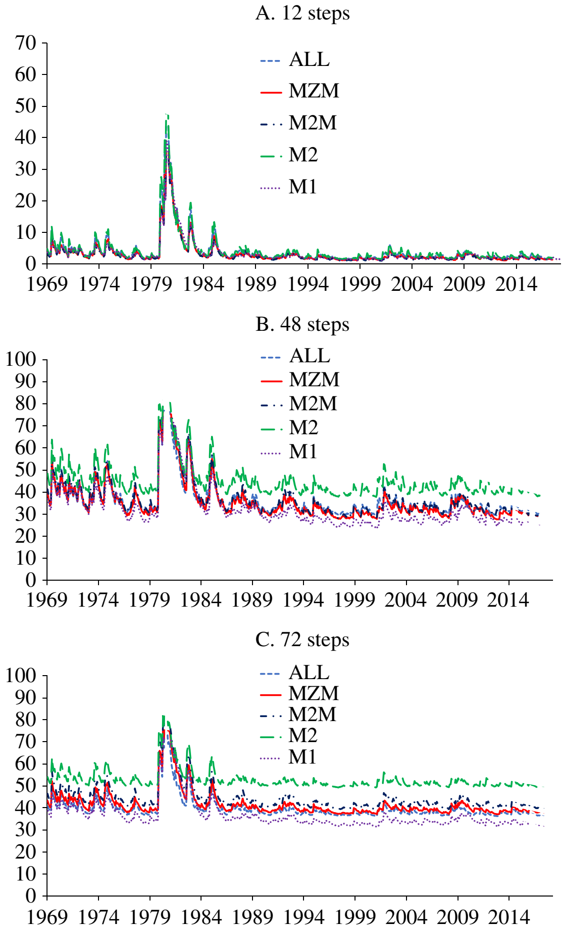

FIGURE 16. Proportion of ouput variance explained by MPS with narrow Divisia money

used in the identification of monetary policy. Generally, MPS explain a greater proportion of output variance if Divisia M3 is used as the definition of money in the monetary policy rule. A similar comparative analysis is performed using narrow definitions of Divisia money in Figure 16. We see that using Divisia M2 in the identification of the monetary policy enhances the explanatory power of MPS in explaining variations in output. Finally, Figure 17 provides a similar comparison using the best narrow and broad monetary aggregates as determined in Figures 15 and 16—Divisia M2, Divisia M4-, and Divisia M3. Though not apparent at 12 steps, by 48 steps, MPS have improved ability of explaining the variations in output when we identify monetary policy using the Divisia M2 definition relative to using either Divisia M3 or Divisia M4-. At 72 steps, using Divisia M2 in the identification of the monetary policy rule allows MPS to explain more than 55%

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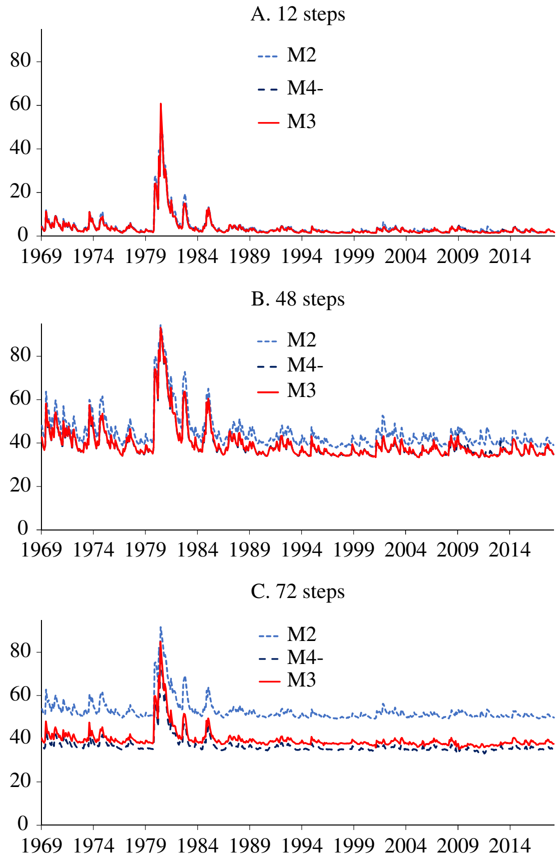

FIGURE 17. Comparison of proportion of ouput variance explained by MPS with narrow and broad Divisia money

of the variation in output while using Divisia M3 allows MPS to explain about 45% of the output variance.

In Figure 18, we present a comparison regarding the proportion of the output variance explained by MDS with narrow and broad money measures at 72 steps. It is obvious in this figure that the explanatory abilities of MDS are greatly enhanced by the use of broad money compared to narrow money. All broad money measures (M4, M4-, and M3) enable MDS to explain between 16% and 25% of the variation in output compared to Divisia M2 with which MDS can only explain less than 10% of the variation in output. In fact, the Divisia ALL aggregate, which is the broadest of the narrow monetary aggregates, clearly illustrates the point that MDS explain significant variations in output under broad money measures relative to narrow ones. It is also worth noticing the surge in the importance of MDS in

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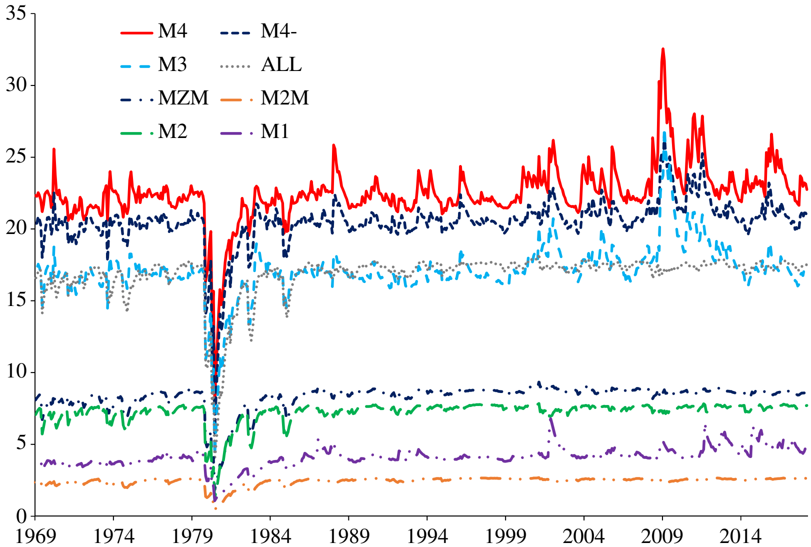

FIGURE 18. Comparison of proportion of ouput variance explained by MDS with narrow and broad Divisia money

explaining variations in output during the 2007–2009 global financial crisis under broad money measures but not with narrow money measures.

We present the price level variance decompositions with Divisia M2 and Divisia M4 in Figures 19 and 20, respectively. These figures clearly show the growing importance of MDS in explaining variations in the price level relative to MPS and MSS. In particular, MPS, with the exception of the 1980 to 1985 period, typically explain about 10% of the variation in prices. MDS on the other hand turn to gradually increase in importance and by 72 steps, become even more important than price shocks in explaining variation in prices. Figures 19 and 20 also show that at 12 steps, money supply shocks account for almost 50% of the variation in prices during the 2001–2002 and 2007–2008 periods. This is particularly obvious with the broad Divisia M4 aggregate (see Figure 20). Figures 21, 22, and 23 provide a comparison as to under which monetary aggregates MDS account for a larger fraction of price level variation. As shown in Figure 23, Divisia M3 is preferred, and Divisia M4 on average does not perform worse than Divisia M2.

In general, MPS dominate MDS and MSS in explaining the variations in output, while MPS and MSS are dominated by MDS in explaining variation in prices. Also, the time-varying variance decomposition analysis enables us to isolate the dominant shocks for some of the most important monetary policy regimes over the sample period. In particular and with regard to output variation, MDS dominate MPS and MSS over the 2001–2002 and 2007–2008 periods, the latter being the period of the global financial crisis, the Great Recession, and of unconventional monetary policies. MPS are the most important shocks during the 1980–1983

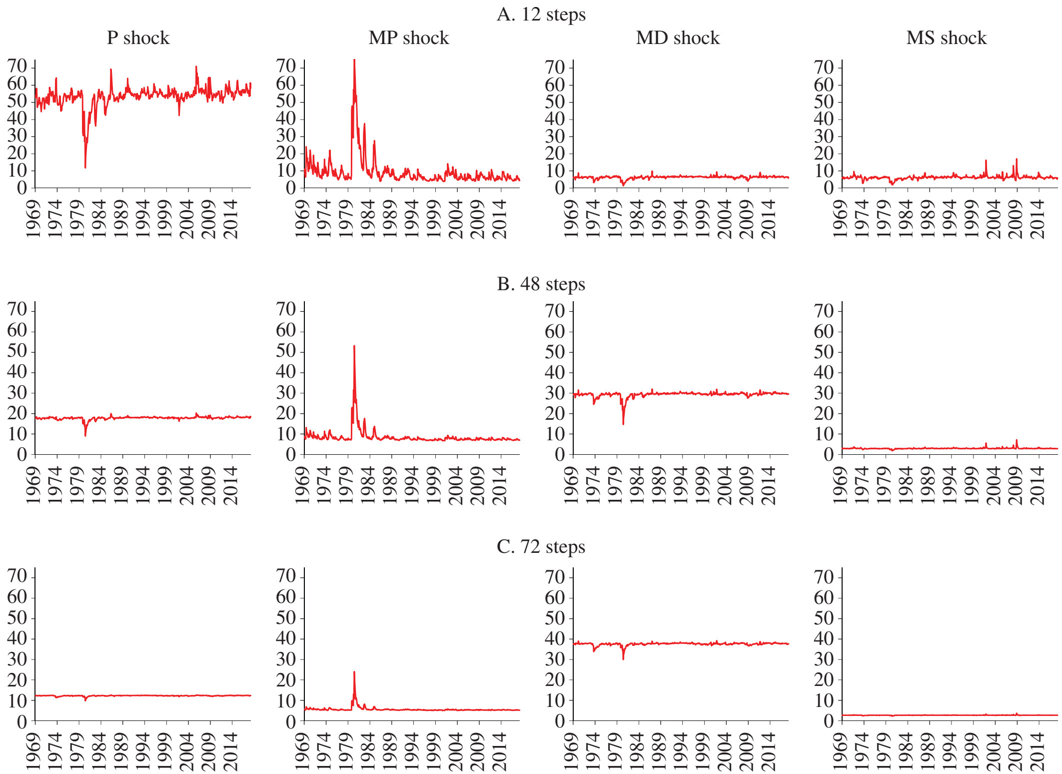

FIGURE 19. Price variance decompositions with Divisia M2

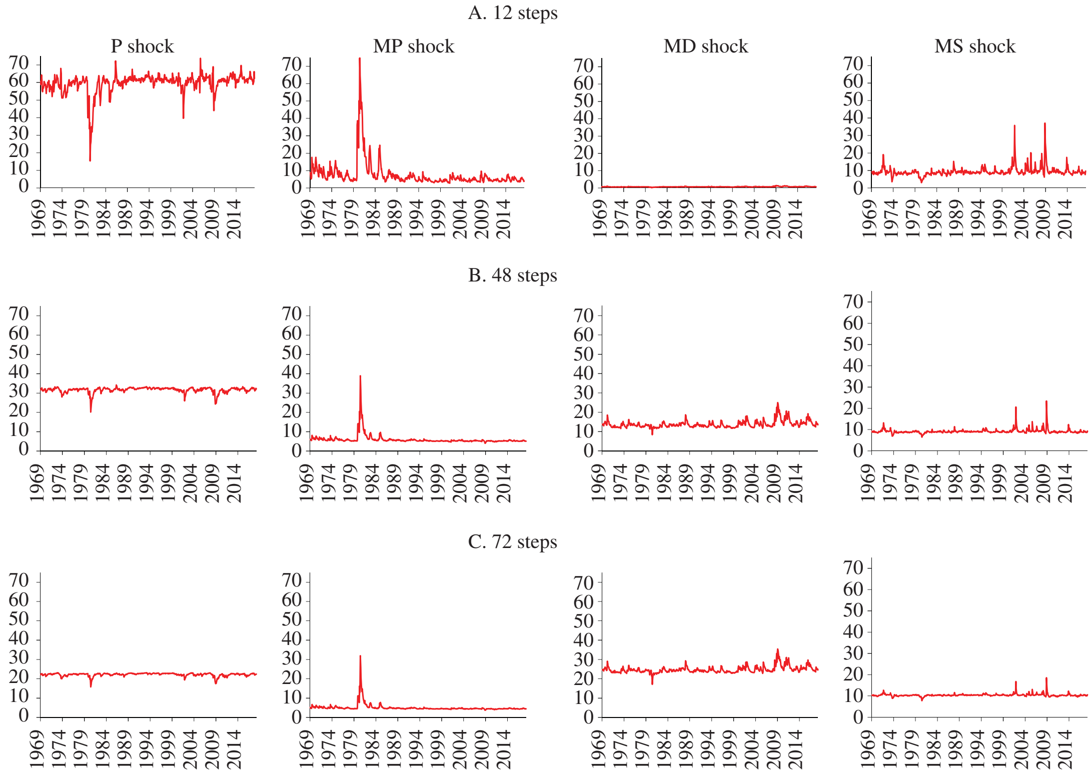

FIGURE 20. Price variance decompositions with Divisia M4

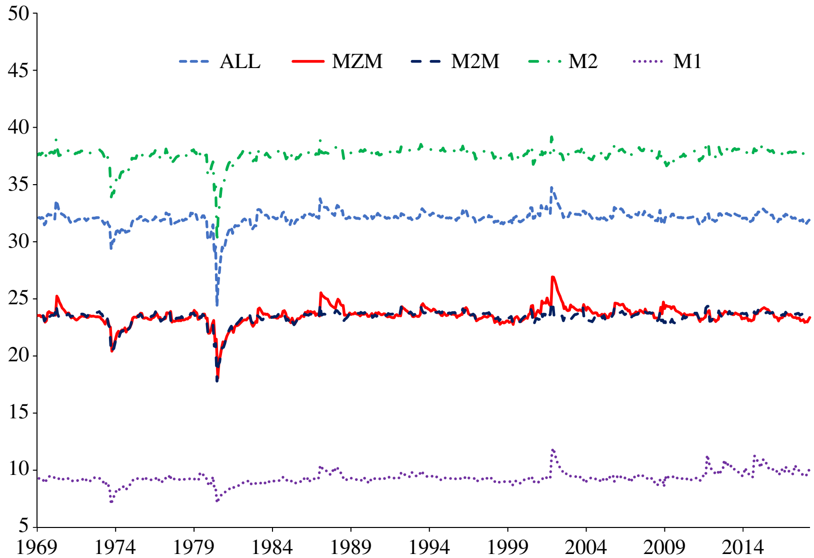

FIGURE 21. Proportion of price variance explained by MDS with narrow Divisia money

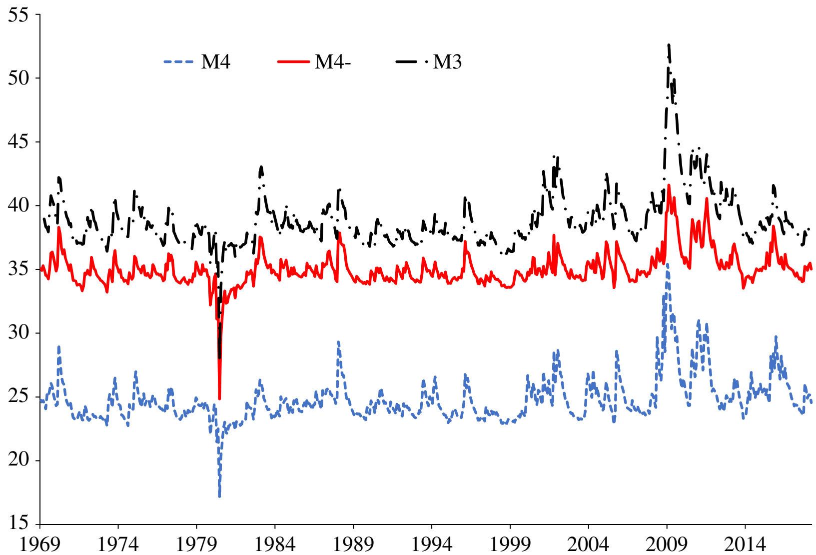

FIGURE 22. Proportion of price variance explained by MDS with broad Divisia money

period; this is the period during which the Federal Reserve de-emphasized the federal funds rate as an operating instrument and conducted a policy of monetary targeting, using nonborrowed reserves as the primary operating instrument and monetary aggregates as intermediate targets. With regard to price level variation,

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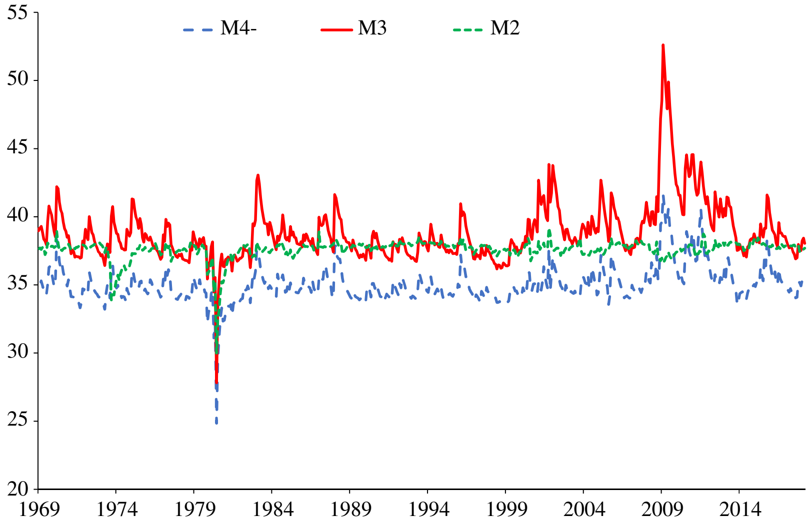

FIGURE 23. Comparison of proportion of price variance explained by MDS with narrow and broad Divisia money

MPS are the most important shocks during the 1980–1983 period while the 2001–2002 and 2007–2008 periods are dominated by MDS and MSS.

7. CONCLUSION

In this paper, we follow Kydland and Prescott (1990) and examine the cyclical behavior of Divisia money (on various definitions), using the new Hamilton (2018) regression filter, to extract the cyclical components. We find that broad Divisia monetary aggregates (at the M3, M4-, and M4 levels of aggregation) are weakly procyclical, whereas narrow Divisia monetary aggregates (at the M1, M2, M2M, MZM, and ALL levels of aggregation) are acyclical. These findings support a monetary effect on the business cycle and illustrate the importance of the broad (superlative) Divisia monetary aggregates, reinforcing the claims by Barnett (2016) and Jadidzadeh and Serletis (2019) that we should employ the broad Divisia monetary aggregate published by the CFS.

We also follow Bernanke and Blinder (1992) and Belongia and Ireland (2015) and use the notion of Granger (1969) causality to investigate the relative information content of interest rates and various narrow and broad Divisia definitions of money in explaining variations in a number of alternative indicators of real economic activity. We find that the broad Divisia monetary aggregates are superior over the narrow Divisia monetary aggregates in forecasting movements in real activity. Also, contrary to the general conclusion by Sims (1980a) and Litterman and Weiss (1985), the predictive power of Divisia money is not absorbed by

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the presence of the interest rate. Moreover, contrary to Friedman and Kuttner (1992), focusing on data from the post-1980 period does not weaken the evidence indicating significant relationships between Divisia money and economic activity.

Moreover, we investigate the relationship between money and economic activity in the context of six-variable structural VAR and by allowing for GARCH behavior in the structural shocks. As in Leeper and Roush (2003) and Belongia and Ireland (2016), we identify MPS with innovations in the interest rate, using a Taylor-type monetary policy rule that includes money together with prices and output. We provide evidence that money matters in describing the effects of monetary policy. Our results reinforce those in Leeper and Roush (2003) and Belongia and Ireland (2016), and as in Belongia and Ireland (2016, p. 268) "call into question the conventional view that the stance of monetary policy can be described with exclusive reference to its effects on interest rates and without consideration of simultaneous movements in the monetary aggregates." Moreover, the performance of the structural VAR improves significantly if broad Divisia money measures are used when identifying MPS. In particular, contractionary MPS elicit a less pronounced contraction in output when the broad Divisia monetary aggregates are used in the measurement of monetary policy instead of the narrow Divisia monetary aggregates. Also, broad Divisia money measures diminish (although do not eliminate) the price puzzle relative to narrow ones.

Overall, our results favor the group of broad monetary aggregates, including Divisia M3, Divisia M4-, and Divisia M4. However, the causality test results, and to a lesser extent the variance decompositions, are particularly strong for Divisia M3 and Divisia M4-, as opposed to Divisia M4, suggesting that to get the tightest link between the monetary aggregate and output, it seems best to use one of the broad Divisia monetary aggregates, but excluding treasury bills.

We believe that our detailed statistical analysis will prove useful in solving the "Barnett critique," in guiding future work that models theoretically the demand for money, and in restoring a meaningful role for superlative (Divisia) measures of money within dynamic stochastic general equilibrium frameworks.

SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1365100519000890.

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