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Money Demand Accommodation: Impact on Macro-Dynamics and Policy Consequences

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ABSTRACT

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Abstract

In this paper we account for the U.S. Fed's response to money demand shocks by allowing for less-than-complete accommodation in the estimation of the Fed's money supply policy rule. We find a significantly lower degree of money accommodation in the 1979-1982 period, which hints at money targeting during that period rather than interest rate targeting. We identify the path of money demand and money supply shocks and comment on their effects on the dynamic behavior of money, interest rates, output and inflation: the monetary policy intermediate target seems not to be the key determinant of macro dynamics. Our results allow us to offer comments on the implications for monetary policy of both the degree of money demand accommodation -thus, of the intermediate monetary policy target- and the evolution (reduction) of macroeconomic volatility between 1984 and 2007.

JEL Classification: E32, E41, E52, E58

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1. Introduction

Whether (and how) money demand shocks have historically influenced the path of interest rates and other macro variables remains an empirical question.[1] Indeed, most of the work on empirical monetary policy rules has ignored this possibility. A number of studies draw conclusions on the Fed's monetary policy stance before and after 1979 without any reference to money demand shocks (see, for example, Clarida et al., 1999, or the papers in Taylor, 1999).[2] This paper is an attempt to integrate money demand shocks into the analysis of monetary policy and to assess the impact in U.S. macro fluctuations of different policy rules regarding money demand shocks.

The widespread omission of money demand shocks in the empirical analysis of monetary policy is probably a consequence of the emphasis placed by New-Keynesian models -the current benchmark of most empirical monetary policy analyses- on interest rate reaction functions. If the interest rate is assumed to be the intermediate target through a monetary policy reaction function, the money market is always assumed to clear by having the Central Bank adjust the stock of money so that the equilibrium in the money market is consistent with the interest rate implied by the reaction function. In other words, if there were money demand shocks, the Central Bank would always perfectly accommodate them. Although the assumption is not explicitly stated, the setting also assumes that the role of money stocks is secondary and that the only transmission mechanism is the real interest rate channel. Empirical evidence of significant effects of money stocks on output and inflation (see for example, Honokan, 1991; Us, 2004; Belke and Polleit, 2006, among others), however, has recently led researchers to complement the New-Keynesian model with money stocks (see Leeper and Zha, 2000, and Leeper and Roush, 2003, for empirical analyses or Collard and Dellas, 2005, for a theoretical framework where money demand shocks are explicitly included). This paper is an attempt to give a further step in this direction by investigating whether the Fed procedures have caused money demand shocks to play a significant and distinct role in the fluctuations of U.S. macroeconomic variables from 1970 to 2007.

The paper makes two main contributions. First, we explicitly allow for less-than-perfect accommodation of money demand shocks by the Federal Reserve and estimate the degree of accommodation across alternative periods. We find that the degree of money

[1] This type of shocks may stem from temporary changes in the liquidity preferences of consumers (think, for instance, of the recent financial crisis as leading to a large increase in the willingness of consumers to hold liquid money), financial developments that lead to lower needs for cash or transitory changes in financing conditions.

[2] Other papers that have analyzed money demand are Akinlo (2006), Nagayasu (2003), Apergis (1997) and Cuthbertson and Taylor (1990) among others.

demand shock accommodation was significantly smaller during the money targeting period 1979-1982. An important implication of this result is that interest rate dynamics become significantly related to money demand shocks, as our estimates reveal. Additional findings are, first, that monetary policy was significantly procyclical during the 1970's and early 1980's but not so afterwards. Second, we find an implied interest rate response to expected inflation not significantly different across sample periods and less strong than usually found with complete money demand shock accommodation.

A second contribution of the paper is to differentiate money demand and money supply shocks and to analyze separately their impact on macro dynamics. Among other results, our analysis reveals that the price puzzle is still present in the pre-1979 period, but it disappears afterwards, leading to "correct" macro dynamics even in the context of a VAR-type analysis. This result is consistent with Hanson (2004).

We identify money demand shocks in a stylized simultaneous equation system where the Fed is allowed to choose the degree of accommodation of these shocks. The money demand shock is identified as a residual of a standard money demand function whereas the money supply shock is the residual of a real money supply rule. By assuming that the market for money stocks clears period by period, the parameters of the implied interest rate rule are functions of structural parameters in the money demand function and the endogenous money supply rule.[3]

Other studies have introduced money stocks in the monetary policy rule. Some examples are Leeper and Zha (2000), Ireland (2001) and Andrés et al. (2006). An important difference between our study and theirs is that while these studies let money stocks enter directly into the monetary policy rule, we include the money demand shock in order to capture the degree of money demand accommodation. Our results are, however, fully consistent with theirs in that money matters for interest rate dynamics. Our paper is also related to Bernanke and Mihov (1998). These authors carefully identify the different types of shocks hitting the money market and the Fed's stance regarding those shocks. A differential feature of our paper is that it displays structural elements, as we estimate parameters in the money supply and demand functions. In agreement with Bernanke and Mihov's results, we find that money demand accommodation was significant all throughout the sample except during the 1979-1982 money targeting period. Finally, and consistent with the results in Leeper and Roush

[3] Galí (1992) also estimated a model with money supply and money demand functions, but some important differences have to be noted. First, we allow for an endogenous real money supply response to macro fluctuations whereas Galí's policy shock is the first difference of nominal money supply. Second, our inflation and output equations, instead of being structural, are left unconstrained. This feature has the advantage of letting both money stocks and the interest rate affect inflation and output directly. As we show below, both channels turn out to be relevant. Third, we allow our money shocks to be autocorrelated which helps to reduce the problems induced by the high persistence of variables such as the interest rate.

(2003), we reject on empirical grounds the New-Keynesian model assumption that the only transmission mechanism is through (nominal or real) interest rate dynamics. Taken together, our results reinforce the view that money stocks matter empirically.

The structure of the paper is as follows. Section 2 presents a simple theoretical framework for both the money market and for inflation and output dynamics. Section 3 estimates the theoretical model for four distinct periods in which the operating procedures of the Fed have traditionally been described as being significantly different. Implications of the parameter estimates are first described and then the impact of monetary policy on the dynamics of the main macroeconomic variables is studied in detail. Section 4 concludes.

2. A Simple Model of the Money Market

We assume a simple economy where the money demand schedule is given by:

$$m_t^d = \theta y_t - \zeta i_t + \varepsilon_t^d, \tag{1}$$

where m_t^d is real money demand at time *t*, y_t is the output gap between *t-1* and *t*, i_t is the average nominal interest rate between time *t-1* and time *t* and ε_t^d is the exogenous money demand shock at time *t*. For the monetary authority (Federal Reserve), we propose the following endogenous money supply process:

$$m_t^s = -\psi E_t \pi_{t+1} - \varpi y_t + \nu \varepsilon_t^d - \varepsilon_t^p, \tag{2}$$

where m_t^s is real money supply, E_t is the rational expectations operator conditional on information known at time *t*, π_t is period *t* inflation and ε_t^p is the exogenous –contractionary- monetary policy shock. The coefficient v ($0 \leq v \leq 1$) measures the degree of money demand shock accommodation by the Federal Reserve. In our symmetric information framework, the Fed is able to exactly identify the exogenous money demand shock from the money demand equation (1). Indeed, the possibility that v may be different from one is precisely the key feature in our money supply process compared to those implicitly embedded in standard interest rate rules.

Money market clearing requires that

$$m_t^d = m_t^s \tag{3}$$

so that

$$i_t = \beta E_t \pi_{t+1} + \gamma y_t + \varphi \varepsilon_t^d + \chi \varepsilon_t^p, \tag{4}$$

Equation (4) implies the following cross-equation parametric restrictions:

$$\beta = \frac{\psi}{\zeta}, \qquad \gamma = \frac{\theta + \varpi}{\zeta}, \qquad \varphi = \frac{1-\nu}{\zeta}, \qquad \chi = \frac{1}{\zeta}.$$

Note that (4) is an implied equilibrium condition which embeds both the stance of the monetary policy authority as well as the private sector behavior. Indeed, an interesting feature of our approach is that it allows us to identify and estimate both sets of structural parameters. We believe that the equilibrium condition is realistic, not very restrictive and allows us to relate our estimates to others found in the empirical monetary policy rules and money demand literatures. It becomes clear that if the monetary authority fully responds to money demand shocks (v = 1), then the interest rate does not react directly to money demand shocks. In this instance, we recover a standard monetary policy specification such as that proposed by Taylor (1993). However, insofar as the money demand shocks are not fully accommodated, $v \in [0; 1)$, they influence the interest rate path beyond their potential impact on expected inflation and output. This is the main differential feature of our modelling of monetary policy and one whose adequacy we test explicitly in section 3.

We further allow both the exogenous money supply and demand shocks to follow AR(1) processes in order to account for the persistence of money market variables:

$$\varepsilon_t^d = \rho_d \varepsilon_{t-1}^d + \eta_t^d, \qquad \eta_t^d \to \mathrm{N}(0, \sigma_\mathrm{d}), \tag{5}$$

$$\varepsilon_t^p = \rho_p \varepsilon_{t-1}^p + \eta_t^p, \qquad \eta_t^p \to \mathrm{N}(0, \sigma_\mathrm{p}). \tag{6}$$

Combining equations (1) and (5) yields:

$$m_t - \rho m_{t-1} = \theta(y_t - \rho_d y_{t-1}) + \zeta(i_t - \rho_d i_{t-1}) + \eta_t^d. \tag{7}$$

Combining equations (1), (4) and (6) yields:

$$(1-\varphi\zeta)(i_t - \rho_p i_{t-1}) = \beta(E_t\pi_{t+1} - \rho_p E_{t-1}\pi_t) + \\ + \varphi(m_t - \rho_p m_{t-1}) + (\gamma - \varphi\theta)(y_t - \rho_p y_{t-1}) + \chi\eta_t^p \tag{8}$$

Since our focus is on the dynamics of the money market, we let inflation and output depend on a reduced-form VAR(1) of all macro variables:

$$\pi_t = a_{11}\pi_{t-1} + a_{12}y_{t-1} + a_{13}i_{t-1} + a_{14}m_{t-1} + \eta_{\pi,t}, \qquad \eta_{\pi,t} \to \mathrm{N}(0, \sigma_\pi), \tag{9}$$

$$y_t = a_{21}\pi_{t-1} + a_{22}y_{t-1} + a_{23}i_{t-1} + a_{24}m_{t-1} + \eta_{y,t}, \qquad \eta_{y,t} \to \mathrm{N}(0, \sigma_y). \tag{10}$$

The money market shocks have no contemporaneous effects on either output or inflation, as in Svensson (1997) or Christiano et al. (1999). However, we allow for the real money stock to affect output and inflation with a lag. Thus, monetary policy affects macro dynamics through two different channels: money and the interest rate.

Equations (7), (8), (9) and (10) constitute our macroeconomic system, which can be expressed as:

$$B_{11}X_t = A_{11}E_tX_{t+1} + A_{12}E_{t-1}X_t + B_{12}X_{t-1} + G\eta_t, \qquad \eta_\mathrm{t} \to N(0, D), \tag{11}$$

where $X_t=(\pi_t \;\; y_t \;\; i_t \;\; m_t)$, A_{11}, A_{12}, B_{11}, B_{12} and G are matrices of parameters and η_t is the vector of exogenous i.i.d. shocks with diagonal variance matrix D. The rational expectations solution implies a reduced-form VAR(1) which can be obtained through numerical methods as in Sims (2002) or Cho and Moreno (2008):[4]

$$X_t = \Omega X_{t-1} + \Gamma \eta_t. \tag{12}$$

3. Empirical Results

We estimate the above macroeconomic system using data for the US, for the period 1970-2007, ending right before the beginning of the financial crisis. Our analysis takes a historical approach: we distinguish four different subperiods in our data, which correspond to four relevant periods traditionally identified regarding the Fed's monetary policy stance. After describing the data employed, we comment on the parameter estimates across subperiods and test some of the restrictions implied by our money market model. We comment on the path of the estimated money demand and money supply shocks and on their relationships with the money market variables. We then analyze the impact of these shocks on macroeconomic dynamics and, therefore, on the implications for monetary policy. This allows us to offer comments on the effects of different monetary policies –specifically, on the effects of the different degree of money demand shock accommodation-.

3.1 Data and Estimation

We use quarterly data from 1970:Q1 to 2007:Q2. The Consumer Price Index (CPI), collected from the Bureau of Labor Statistics, is used to construct our inflation measure. The output measure is real Gross Domestic Product (GDP), from the NIPA tables. We use the Federal funds rate and M2 as the short-term interest rate and the money supply measures, respectively. Both variables were collected from the Board of Governors website. Since GDP and M2 exhibit upward trends, we use an HP-filtered version of both variables.

Estimation of the model's parameters has been carried out using a two-step Bayesian procedure with the DYNARE econometric package. In the first step, the log posterior function is maximized in a way that combines the prior information of the parameters with the empirical likelihood of the data. In a second step, we perform the Metropolis-Hastings algorithm to compute the posterior distribution of the parameter set. Table 1 shows the priors and the posteriors of the structural parameters of interest. The prior

[4] Note that the system is over-identified: there are 19 parameters in our macro model and 26 in the VAR. Thus, our model can be expressed as a restricted VAR. The restrictions precisely allow us to identify the structural macro shocks and the parameters of the monetary policy and money demand functions.

distribution of the standard deviation of all shocks is inverse gamma, and that of the first order autocorrelation coefficients of the shocks is beta. The prior distribution of the remaining parameters is Gaussian. We pick prior means and standard deviations so as to extract as much information as possible from the data. For instance, the prior mean of the key accommodation parameter, *v*, is 0.5, with standard deviation 0.5.

3.2 Parameter Estimates: A Historical Approach

We estimated our model with the data split into four different subperiods: 1970:Q1-1979:Q3, 1977:Q1-1982:Q4, 1984:Q1-2001:Q2 and 2001:Q3-2007:Q2.[5] Tables 1 and 2 show, respectively, the structural parameter estimates of our macro model for the different subperiods and the coefficients of the implied interest rate rule (equation (4)). We emphasize that the implied interest rate rule is an equilibrium condition, since our policy equation is equation (2). All estimations yielded unique and stable solutions. We comment now on the results by subsamples placing special emphasis on the relationship between the Fed's procedures and our parameter estimates (most importantly, the accommodation parameter *v*).

The 1970-1979 period remains highly controversial for monetary economists. It coincides with the run-up of inflation and the tenure of Arthur Burns as Federal Reserve chairman. While some economists have blamed the inflation of the 70s on the inertia of oil shocks (Blinder, 1982), others have pointed at the Fed's lax policies, which may have been the result of its lack of mandate (De Long, 1997) or of its wrong understanding of the economy (Romer and Romer, 2002). Research by Judd and Rudebusch (1998), Clarida et al., 1999) and others has found that the Fed did not react strongly enough against inflation during the pre-1979 period, whereas it did after Volcker's arrival at the Fed. Mishkin (2003) points out that while the Fed announced in 1970 its commitment to use monetary aggregates as intermediate targets, the commitment was not very strong and the targets were consistently missed. In effect, the Federal Open Market Committee would set ranges for both the growth rate of both money aggregates and the Federal funds rate.

Our estimates suggest that during this period the Fed was probably more focused on targeting the Federal funds rate than monetary aggregates: *v* is quite close to, although significantly lower than, one. This suggests that the Fed *modus operandi* was closer to interest rate targeting than to money targeting but that the interest rate targeting was not, as suggested by the above mentioned references, effectively achieved. Moreover, and as suggested by Mishkin (2003), monetary policy was procyclical during this period, since our estimate of ϖ is significantly negative. Note that one advantage of

[5] This choice of subperiods will be justified throughout the discussion of the results.

our separate analysis of money demand and supply, is that we can decompose the interest rate reaction to output gap (coefficient γ in equation (4)) in two parts. On the one hand, we have the elasticity of the money demand to output, which is significantly positive (0.62). On the other hand, we have the endogenous money supply response to output fluctuations. Because the former is larger than the latter, the interest rate response to output is positive in equilibrium, as table 2 reveals. By looking at the implied interest rate response to output, one would, incorrectly, conclude that monetary policy was countercyclical, when in reality the evidence suggests that it was significantly procyclical. Note that the estimates also show a large elasticity of the money demand to the interest rate (ζ is 0.72 and significantly different from zero) and a not-too-strong reaction of the Fed to inflation (ψ is only 0.45, which yields an estimate of the implied interest rate reaction to inflation of β=0.62).

Data for the second subperiod start at the beginning of 1977 and finish at the end of 1982. The subperiod includes the 1979-1982 experience with money targeting. Since our data are quarterly, the 1979-1982 period includes only twelve observations (the announced money targeting period went from October 1979 to October 1982), insufficient to estimate the nineteen parameters of our model. Therefore, we include several additional observations around the money targeting period in order to allow for the estimation.[6] Table 1 shows that the Fed hardly accommodated money demand shocks during this second subsample. Our estimate of v is 0.44, significantly different from one, and quite close to, though significantly different from, zero. While the Fed did miss the money targets during 1979-1982, this result is consistent with the evidence in Bernanke and Mihov (1998) that money demand shocks were not routinely accommodated during this period. The fact that v is close to zero and that φ is close to one (table 2) is also consistent with the increased interest rate volatility (table 4) given that money demand now affects the interest rate directly. The Fed reduced the procyclicality of monetary policy during these years (the estimate of ω is still negative, but much smaller and not significantly different from zero). It also reacted more significantly to inflation, ψ=0.63 and the equilibrium response to inflation is the highest across subperiods (β =1.03). This result comes as no surprise, since the period includes the peak of inflation and the Volcker disinflation. The money demand elasticity to the interest rate is again quite large, although smaller than in any other subperiod. Finally, it is worth mentioning that during this subperiod both the money supply and

[6] A robustness analysis where the model is estimated for alternative subsamples of this second subperiod is available from the authors. The differences, especially with respect to the parameter v, were not significant, although the more observations from other subperiods that were included, the higher the estimate of v, which clearly favors our conclusion of 1979-1982 being a money targeting period with v close or equal to zero.

money demand shocks are much higher than in the other subsamples, and also the variance of all macroeconomic variables -except money- is the largest of all subperiods. This suggests, again, a strong interest by the Fed to target money aggregates rather than the interest rate, and sharp movements in output and inflation as a consequence of the disinflation effort.

(Insert Table 1 about here)

The third subsample covers the 1984-2001 period. During these years inflation was mostly under control and the conduct of monetary policy has been by and large praised by policy makers and academics alike. This period is also acknowledged to display larger output stability (see McConnell and Quirós (2000)). According to Mishkin (2003), the Federal funds rate became the Fed's target during this period, especially after 1994, when the Fed started to announce periodically a target for the Federal funds rate. Table 1 shows that the money supply response to output is small and non-significantly procyclical. We find that during this period the Fed shrank the money growth process in response to inflationary pressures with a similar intensity to the pre-Volcker period (the estimates of ψ are indeed similar across periods). The degree of money demand accommodation is close to and significantly indistinguishable from one, pointing at a clear interest rate targeting strategy from the Fed. It is noteworthy that even with v close to one (and φ close to zero), our implied estimate of β (0.67) is much lower than previous estimates in the literature for this period. Thus, it is clear that the less-than-perfect money demand shock accommodation leads to very different conclusions on the implied interest rate response to inflation. As these shocks exhibit a high degree of autocorrelation (between 0.6 and 0.9 across periods), this opens up an additional explanatory channel for interest rate dynamics.

Our fourth subsample goes from 2001 to 2007. The rationale for the choice of this subperiod is twofold. First, in the third quarter of 2001, the Fed starts pursuing an aggressive expansionary policy in response to the recession and the terrorist attacks. Second, several authors and policy analysts have criticized the Fed's policy during this year, defining it as overly expansionary, judging from the positive differential from the interest rate implied by a standard Taylor rule and the actual one (see Taylor, 2009). Therefore, we end the subsample in the second quarter of 2007, right before the beginning of the financial crisis. Table 1 shows that, in contrast to the other three periods, the Fed lowered the money stock in response to increases in output, thus acting in a countercyclical manner. With respect to inflation fluctuations, it lowered the money supply in response to an inflation increase with a similar intensity to the other periods (ψ=0.63). Finally, the Fed perfectly accommodated money demand shocks, as

the point estimate of *v* is 1.18 and not statistically different from one. Table 2 shows that the parameters implied in the equilibrium interest rate response function are similar to those in other periods, with the exception that the response to the money demand shock becomes slightly negative. As a result, the systematic monetary policy management in this subsample can be considered to be quite similar to that of the 1984-2001 period.

We now comment on the standard deviation of the structural shocks. In agreement with the evidence in Sims and Zha (2006), who find shock volatility drifts, the standard deviations of the structural shocks are clearly higher in the second period. This is not surprising since the end of the 70s and beginning of the 80s witnessed increased macroeconomic instability. For instance, the second oil shock took place during these years, leading to more volatile inflation shocks. The monetary policy authority struggled during this period to keep inflation under control and the monetary policy shock is almost twice as large as in the other two subsamples. Cogley and Sargent (2005) also show that the volatilities of these two shocks increased during this period. Regarding the output shocks, the second subsample includes a deep recession, leading to an enlarged negative output shock. Consistent with the "Great Moderation" literature (McConnell and Quirós, 2000; Stock and Watson, 2003)), output shocks were substantially smaller in the post-1984 samples. Finally, the money demand shock is also much more volatile during the second period than in the rest of the sample. As Mishkin (2003) points out, the intense financial innovation and deregulation of the early 80s can be interpreted as a shock to the money demand, which would justify our estimated higher volatility.

Finally, with respect to the monetary policy transmission mechanisms, we allow for the simultaneous effects of current interest rates and money stocks on future inflation and output dynamics (equations (9) and (10)). As table 3 shows, the elasticity of inflation and output to money changes is always positive. It is statistically significant in the first period for both inflation and output, and in the third and fourth period for inflation. With respect to the interest rate channel, the elasticity is always positive in the case of inflation (and statistically significant in the first and third periods) and negative in the first three subsamples in the case of output (but never statistically significant). Thus the money channel seems to be the more stable one, especially with respect to inflation dynamics. This finding casts some doubts on the validity of models which include the interest rate as the only relevant transmission mechanism, such as the minimalist three-variable, three-equation New-Keynesian macro system, where the only relevant monetary policy channel is the real rate effect on output combined with the Phillips curve.

(Insert Tables 2 to 3 about here)

3.3 Macroeconomic Dynamics: 1970-2007

In the following subsection we analyze the impact of money supply and money demand shocks in the money market, output and inflation. First, we show the implied money demand and money supply shocks and study the effects of these shocks on inflation and output via impulse response and variance decomposition analysis. We then draw some lessons for monetary policy and comment on the developments occurred since the beginning of the financial crisis in the summer of 2007.

3.3.1 Money Shocks

Figure 1 compares the estimated autocorrelated money demand shocks (ε^d_t) along with the path of the Federal funds rate across sample periods. In the first subsample, the money demand shock seems to be leading the interest rate. In contrast, the money demand shock seems to be driving some of the interest rate fluctuations during the 1977-1982 period contemporarily, especially during this latter part of the subsample, coinciding with the money supply targeting period. In the 1984-2001 period, we observe a positive relation between the interest rate and the money demand shock at long frequencies, whereas in the 2001-2007 period, there seems to be no clear relation except in the last years: these latter years display a positive correlation in 2006, but a negative one in 2007. Figure 2 compares the money demand shocks with M2. Overall, the autocorrelated money demand shocks track money supply at low frequencies, across subsamples, especially in the 1970-1979 period. This, we believe, is good evidence that our estimation has correctly identified the shock to money demand.

Figure 3 compares the estimated autocorrelated money supply shocks (ε^p_t) with the path of the Federal funds rate across sample periods. The money supply shocks track the Federal funds rate at low frequencies, especially in the last two subsamples, where they look like a smooth version of the rate series. Figure 4 compares the money supply shocks with M2. There is a clear negative relation between the autocorrelated monetary policy shocks and the money aggregate across periods. This finding is due to the strong interest rate elasticity of money demand found across sample periods. The inverse relationship between the money demand shock and the monetary aggregate is apparent in all periods, which we believe to be good evidence that the shock identified corresponds to monetary policy.

(Insert Figures 1 to 4 about here)

3.3.2 Impulse Response and Variance Decomposition Analysis

Figure 5 displays the impulse responses of the four macro variables to money supply and money demand shocks across sample periods. Table 4 shows data on the implied variance decompositions and the historical and model implied variances of the main variables. Several findings are worth highlighting. The price puzzle -a significant increase in inflation following a contractionary money supply shock, first noted by Sims (1992)- is only present in the first period. Leeper and Roush (2003) were the first to note that the price puzzle disappears when money enters structural VARs. As they point out, the reason is that a monetary policy shock decreases money demand, lowering inflation subsequently. Our estimates reflect this intuition crisply, as the interest rate elasticity of money demand is large and significant. Since the lag of money enters directly and significantly into the inflation equation with a positive sign ($a_{14} > 0$ in all four periods), inflation declines following the contractionary money supply shock. Notice that the interest rate lag enters with a positive sign in the first, third and fourth periods and it is almost zero in the second one. Because this coefficient is very large in the 1970-1979 period, the price puzzle arises then, as it dominates over the money demand effect. One possible interpretation is that the Fed's increases in the interest rate signalled higher inflation rates, perhaps due to the negative experience with inflation in the 70s. Romer and Romer (2000) find that monetary policy actions have helped forecast future inflation over the last thirty years. Interestingly, in their reduced-form regressions, they also find that higher interest rates predict higher inflation and that the corresponding projection coefficients are larger during the 70s. Hanson (2004), performing a rigorous VAR analysis, also finds that the price puzzle is mostly a pre-1979 phenomenon.

Figure 5 also shows that inflation increases following money demand shocks across periods. This finding goes against the logic of the static IS-LM model, but it is a straightforward implication of our semi-structural model, where monetary policy is transmitted through interest rates and money shocks, and where money demand shocks increase money stocks. Our simple model can accommodate this fact, given that the money market always clears. Since an increase in money aggregates predicts future increases of inflation and output, money demand shocks produce an increase in each of the two variables. Notice also that the implied increase in the interest rate is not enough to offset the effect of money stocks on output. In the case of inflation, since higher interest rates predict higher inflation, the inflationary effect of money demand shocks is amplified.

One stylized fact of the impulse response functions is that money supply and money demand shocks have had less influence on the inflation and output dynamics in the

post-1984 period. In other words, money market shocks have not driven aggregate fluctuations during this period. The diminishing relevance of money shocks on output and inflation is in agreement with Moreno (2004) and Boivin and Giannoni (2006), who exclusively focus on monetary policy shocks. In our setting, the variance decompositions in table 4 make more transparent the relative importance of money demand and money supply shocks across subsamples. While money demand and money demand shocks jointly drove around 50% of the inflation and output dynamics in the 1970-1979, they only explain around 20% in the remaining subsamples.

Figure 5 also shows that the interest rate and M2 strongly react to both money demand and money supply shocks. An increase in a money demand shock increases the interest rates and the money stock, whereas a contractionary money supply shock decreases the money stock and increases the interest rate, thus generating a sensible negative liquidity effect in the money market. The variance decompositions confirm that the interest rate and M2 are mostly driven by money supply and money demand shocks across all periods.

Finally, table 4 clearly shows that the variance of all macro variables greatly decreased after 1984. Since after 1984 the macro variables are driven by their equation-specific shocks and table 1 shows that these shocks are significantly smaller in the last two subsamples, we can conclude that the smaller size of the structural shocks is directly related to the lower macroeconomic volatility in the macroeconomy.

(Insert Table 4 and Figure 5 about here)

3.3 Some Lessons for Policy

We now draw some policy lessons from our empirical analysis described above.

- The announced and identified money targeting strategy of the 1979-1982 period implied that the interest rate was mostly driven by money demand shocks (more than 40% of its total variation, according to table 4). As it is now clear, this strategy was indeed effective in lowering the inflation rate.
- After 1984, during the identified interest rate targeting periods, more than 75% of interest rate dynamics are explained by the money supply (policy) shock. Thus, whenever the interest rate monetary policy transmission mechanism is strong, interest rate targeting seems an effective strategy to control output and inflation fluctuations.
- The choice of intermediate policy target (either the interest rate, through perfect money demand shock accommodation, or the money stock) seems not to affect the dynamic response of the remaining macroeconomic variables. Thus, the

choice of the intermediate target can be done on the basis of the preference for interest versus money stock stabilization.

- The transaction motive of money demand seems to be losing relevance after 2001. This has a key implication for policy making under interest rate targeting, since, in our equilibrium setting, this reduces the implied interest rate response to the output gap ($\gamma = \frac{\theta + \varpi}{\zeta}$). In the last subsample, the Fed has indeed adjusted this effect by reacting countercyclically to output gap fluctuations in the money supply rule.
- Inflation and output have been very stable from 1984 to 2007. According to our analysis, during that period they were mostly driven by their own shocks. Thus, it seems on the one hand that the economic environment has been more benign after 1984, confirming previous results in the "Great Moderation" literature. On the other hand, money shocks have not increased output and inflation volatility, even if they are driving most of the interest rate and M2 dynamics. This is evidence of an increased credibility of the monetary policy management by the private sector. Thus, in this enhanced credibility environment, it seems adequate for the monetary policy authority to focus on interest rate and financial markets stabilization, rather than on output and inflation management.

3.4 On the 2008 Financial Crisis

In the build-up towards the 2008 financial crisis, macro variables were behaving in a very stable manner. Figure 6 shows this very clearly, as it plots our four macro series from 2005 to 2009. After the credit crunch of August 2007, the Fed decided to lower the interest rates aggressively in order to mitigate the effects of the upcoming crisis, so that the interest rate was the first variable to react significantly. It wasn't until a year later when the effects of the crisis started to show in the remaining variables: output and inflation decreased drastically and M2 increased steeply. Thus the Fed first lowered interest rates towards the 0% floor and flooded the financial markets with liquidity, increasing M2 very aggressively. Thus, until "normality" is restored, monetary policy probably will have little effect on output or inflation. In fact, and consistent with the last implication in subsection 3.3, monetary policy in the last two years has probably been disconnected from the traditional objectives of output and inflation stabilization, in order to focus on financial system stabilization: massive injections of liquidity have not had a major impact on inflation and output –among other things due to the lack of channelling

of credit from the banks to firms in order to improve their balance-sheets- and will probably take a long time to affect output in a noticeable manner.

Once we are out of the crisis, when data become available we'll probably see a break in the values of the parameters that measure the relationship between money and interest rates, on the one hand, and output and inflation, on the other, and also a break in the parameters of the monetary policy rule itself, since the Fed –and other Central Banks- are right now not looking at output or inflation (or only indirectly) but rather at the financial system's needs for liquidity. At this point in time, however, this conclusion is tentative and not yet testable.

(Insert Figure 6 about here)

4. Conclusions

Much of the current empirical monetary policy analysis abstracts from the influence of money demand shocks on interest rates, inflation and output. We have shown in this paper that this assumption is not completely innocuous: the degree of accommodation of money demand shocks has not always been complete and this affects both monetary policy management and implied macro dynamics. A second goal of our paper was to disentangle the effects of money demand and money supply shocks on macro dynamics. We showed that distinguishing both shocks leads to sensible predictions of the dynamics of output and inflation, and to a better understanding of the workings of monetary policy and its effect on output and inflation. We show, however, that the differences between money targeting or interest rate targeting procedures seem to limit to the behavior of the monetary policy instrument, and there do not seem to be large implications for the dynamics of output or inflation. In the light of the experience of recent years, our results suggest that monetary policy may be "dying of its own success", since the major stabilization of both output and inflation –which is, in part, due to smaller macro shocks, but also to better past monetary policy - are reducing greatly the scope for traditional measures of monetary policy effectiveness. An additional goal of financial system stabilization seems to have been at play in recent monetary policy actions, and this adds a new dimension to traditional monetary policy analysis, which should be of high interest for researchers in the immediate future, especially in the light of the recent crisis suffered by the financial system. Finally, some comments regarding monetary policy in the recent financial crises were also offered as an afterthought of our analysis.

We have stressed the relevance of a money channel additional to the interest rate channel in the transmission of monetary policy actions. One step in the research

agenda would be to device a more complete macro model which allowed for less-than-perfect money demand accommodation and that included money balance effects on both supply and demand specifications. Another item on the agenda is to extend the study to other countries. Of special interest would be Germany and Switzerland, two countries whose Central Banks have explicitly implemented money targeting during several decades. Our analysis may provide a useful explanation of macro dynamics in those settings. Moreover, the results in this paper suggest that our simple setup can give valuable information on the behavior of Central Banks and the private sector for countries with inflation targets or alternative monetary policy strategies.

References

Andrés, Javier, J. David López-Salido, and Javier Vallés, 2006, Money in an Estimated Business Cycle Model of the Euro Area, *Economic Journal* 116, 457-477.

Akinlo, A. Enisan, 2006, The Stability of money Demand in Nigeria: An Autoregressive Distributed Lag Approach, *Journal of Policy Modeling* 28, 445-452.

Apergis, Nicholas, 1997, Inflation Uncertainty, Money Demand and Monetary Deregulation: Evidence from a Univariate ARCH Model and Cointegration Tests, *Journal of Policy Modeling* 19, 279-293.

Belke, Ang, and Thorsten Polleit, 2006, Money and Swedish Inflation, *Journal of Policy Modeling* 28, 931-942.

Bernanke, Ben S., and Ilian Mihov, 1998, Measuring Monetary Policy, *Quarterly Journal of Economics* CXIII, 869-902.

Blinder, Alan S., 1982, Anatomy of Double-Digit Inflation in the 1970s in Christina D. Romer and David H. Romer, Ed., *Inflation, Causes and Effects*, Chicago: University of Chicago Press, pp. 247-280.

Boivin, Jean, and Marc Giannoni, 2006, Has Monetary Policy Become More Effective?, *Review of Economics and Statistics* 88, 445-462.

Cho, Seonghoon, and Antonio Moreno, 2008, The Forward Method as a Solution Refinement in Rational Expectations Models, *Mimeo, Yonsei University and University of Navarra*.

Christiano, Lawrence, Martin Eichenbaum, and Charles L. Evans, 1999, Monetary Policy Shocks: What Have We Learned and to What End? in John B. Taylor and Michael Woodford, Eds., *Handbook of Macroeconomics,* vol. 1A, Amsterdam: North Holland, pp. 65-148.

Clarida, Richard H., Jordi Galí, and Mark Gertler, 1999, The Science of Monetary Policy: A New Keynesian Perspective, *Journal of Economic Literature* 37, 1661-1707.

Cogley, Timothy, and Thomas J. Sargent, 2005, Drifts and Volatilities: Monetary Policies and Outcomes in the Post WW II U.S., *Review of Economic Dynamics* 8, 262-302.

Collard, Fabrice, and Harris Dellas, 2005, Poole in the New-Keynesian Model, *European Economic Review* 49, 887-907.

Cuthbertson, Keith, and Mark Taylor, 1990, Money Demand, Expectations and the Forward Looking Model, *Journal of Policy Modeling* 12, 289-315.

De Long, J. Bradford, 1997, America's Peacetime Inflation: The 1970s in Christina D. Romer and David H. Romer, Ed., *Reducing Inflation: Motivation and Strategy*, Chicago: University of Chicago Press, 247-280.

Galí, Jordi, 1992, How Does the IS-LM Model Fit Postwar U.S. Data?, *Quarterly Journal of Economics* CVII, 709-738.

Hanson, Michael S., 2004, The Price Puzzle Reconsidered, *Journal of Monetary Economics* 51, 1385-1413.

Honokan, Patrick, 1991, Inflationary Impact of Money Financed Deficits, *Journal of Policy Modeling* 13, 229-240.

Ireland, Peter N., 2001, Sticky-Price Models of the Business Cycle: Specification and Stability, *Journal of Monetary Economics* 47, 3-18.

Judd, John P., and Glen D. Rudebusch, 1998, Taylors Rule and the Fed: 1970-1997, *Eco-nomic Review, Federal Reserve Bank of San Francisco* 1, 3-16.

Leeper, Eric M., and Jennifer E. Roush, 2003, Putting M Back In Monetary Policy, *Journal of Money, Credit and Banking* 35, 1217-1256.

Leeper, Eric M., and Tao Zha, 2000, Assessing Simple Policy Rules: A View from a Complete Macro Model, *Federal Reserve Bank of Atlanta. Working Paper 19*.

McConnell, Margaret, and Gabriel Pérez Quirós, 2000, Output Fluctuations in the United States: What has changed since the early 1980s, *American Economic Review* 90, 1464-1476.

Mishkin, Frederic S., 2003, *The Economics of Money, Banking, and Financial Markets, 7th Ed.* (Pearson, Addison-Wesley).

Moreno, Antonio, 2004, Reaching Inflation Stability, *Journal of Money, Credit and Banking* 36, 801-825.

Nagayasu, Jun, 2003, A Re-Examination of the Japanese Money-Demand Function and Structural Shifts, *Journal of Policy Modeling* 25, 359-375.

Romer, Christina D., and David H. Romer, 2000, Federal Reserve Private Information and the Behavior of Interest Rates, *American Economic Review* 90, 429-457.

Romer, Christina D., and David H. Romer, 2002, The Evolution of Economic Understanding and Postwar Stabilization Policy, *NBER Working Paper No 8071*.

Sims, Christopher A., 2002, Solving Linear Rational Expectations Models, *Computational Economics* 20, 1-20.

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

Stock, James, and Mark W. Watson, 2003, Understanding Changes in International Business Cycle Dynamics, *Journal of the European Economic Association* 3, 968-1006.

Svensson, Lars E.O., 1997, Inflation Forecast Targeting: Implementing and Monitoring Inflation, *European Economic Review* 41, 1111-1146.

Taylor, John B., 1993, Discretion versus Policy Rules in Practice, *Carnegie-Rochester Conference Series on Public Policy* 39, 195-214.

Taylor, John B., 1999, *Monetary Policy Rules*. (Chapman & Hall Chicago, IL).

Us, Vuslat, 2004, Inflation Dynamics and Monetary Policy Strategy: Some Prospects for Turkish Economy, *Journal of Policy Modeling* 26, 1003-1013.

Table 1

Posterior Estimates of *Structural* Parameters in the Four Periods

	Prior Mean	**Prior S.D.**	**70:1-79:3**	**77:1-82:4**	**84:1-01:2**	**01:3-07:2**
θ	0.50	0.30	0.616*	0.501*	0.365*	0.244
ζ	1.00	0.30	0.715*	0.605*	0.780*	0.883*
ω	0.50	0.50	-0.461*	-0.289	-0.166	0.117*
v	0.50	0.50	0.797* (0.65,0.92)	0.442* (0.18,0.72)	0.869* (0.62,1.09)	1.178* (0.77,1.52)
Ψ	0.70	0.88	0.445*	0.626*	0.524*	0.748*
σ_d	0.15	0.15	1.259*	1.710*	0.530*	0.703*
σ_p	0.15	0.15	0.572*	0.932*	0.496*	0.545*
σ_y	0.15	0.15	0.786*	1.157*	0.481*	0.369*
σ_π	0.15	0.15	1.358*	2.380*	1.146*	1.643*
ρ_d	0.50	0.15	0.768*	0.607*	0.903*	0.685*
ρ_p	0.50	0.15	0.688*	0.806	0.887*	0.840*

* Denotes that the 90% confidence interval for the parameter does not contain zero. For the money demand accommodation parameter, *v*, we include the confidence interval in brackets.

Table 2

Implied Estimates of the *Equilibrium Interest Rate Rule* Parameters

	70:1-79:3	**77:1-82:4**	**84:1-01:2**	**01:3-07:2**
β	0.622	1.035	0.672	0.847
γ	0.217	0.350	0.255	0.409
φ	0.284	0.922	0.168	-0.202
χ	1.399	1.653	1.282	1.133

Table 3

Posterior Estimates of *Monetary Policy Transmission* Parameters

	Prior Mean	**Prior S.D.**	**70:1-79:3**	**77:1-82:4**	**84:1-01:2**	**01:3-07:2**
a_{13}	-0.10	0.50	0.452*	-0.029	0.229*	0.132
a_{23}	-0.10	0.50	-0.108	-0.009	-0.003	0.013
a_{14}	0.10	0.50	0.189*	0.376	0.367*	0.418*
a_{24}	0.10	0.50	0.256*	0.224	0.026	0.039

* Denotes that the 90% confidence interval for the parameter does not contain zero.

Table 4

Historical and Model Implied *Standard Deviations* of Macro Variables and Proportion of *Variance Decomposition* Attributed to the Monetary Shocks

		70:1-79:3	**77:1-82:4**	**84:1-01:2**	**01:3-07:2**
Output	σ_{Hist}	1.814	1.764	0.819	0.492
	σ_{Model}	1.576	2.098	1.017	0.625
	% η^d	0.239	0.173	0.065	0.091
	% η^p	0.294	0.168	0.120	0.111
Inflation	σ_{Hist}	2.981	3.421	1.414	1.669
	σ_{Model}	3.594	3.827	1.408	1.667
	% η^d	0.384	0.114	0.245	0.079
	% η^p	0.116	0.113	0.052	0.023
Money	σ_{Hist}	3.325	1.988	1.319	1.104
	σ_{Model}	2.316	1.836	1.464	1.165
	% η^d	0.450	0.397	0.372	0.589
	% η^p	0.410	0.296	0.609	0.401
Interest rate	σ_{Hist}	2.582	3.948	1.986	1.608
	σ_{Model}	2.379	3.894	1.496	1.125
	% η^d	0.363	0.416	0.141	0.104
	% η^p	0.425	0.191	0.760	0.855

Figure 1

Interest Rates (Demeaned) and Money Demand shocks (Subsamples)

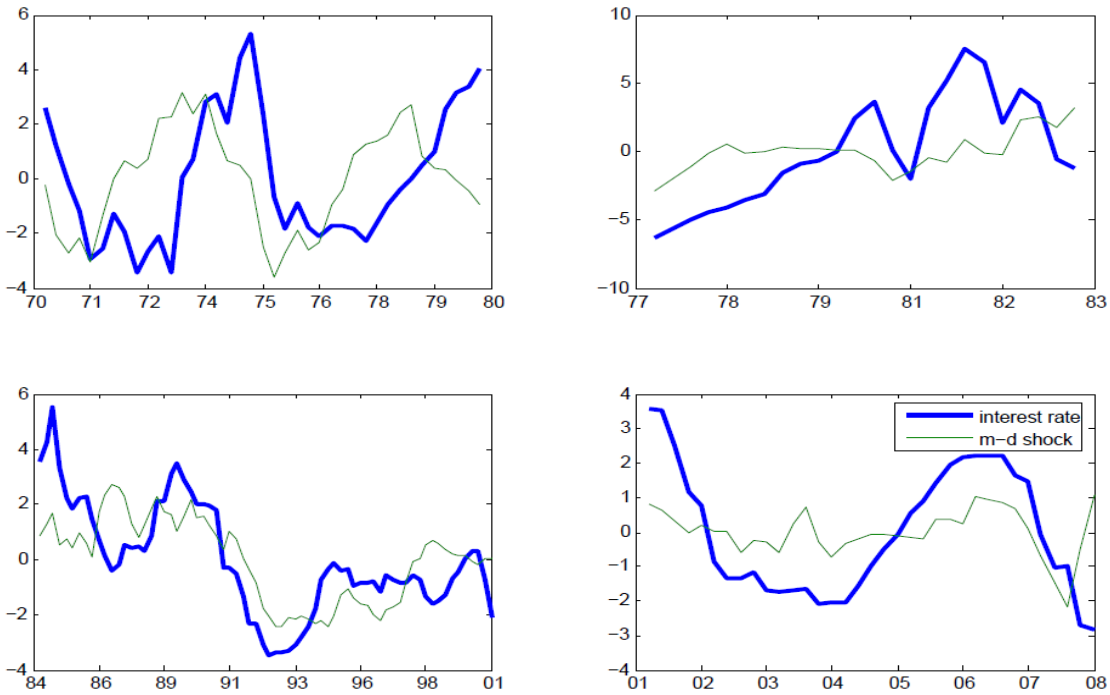

Figure 2

Money Supply (Detrended) and Money Demand shocks (Subsamples)

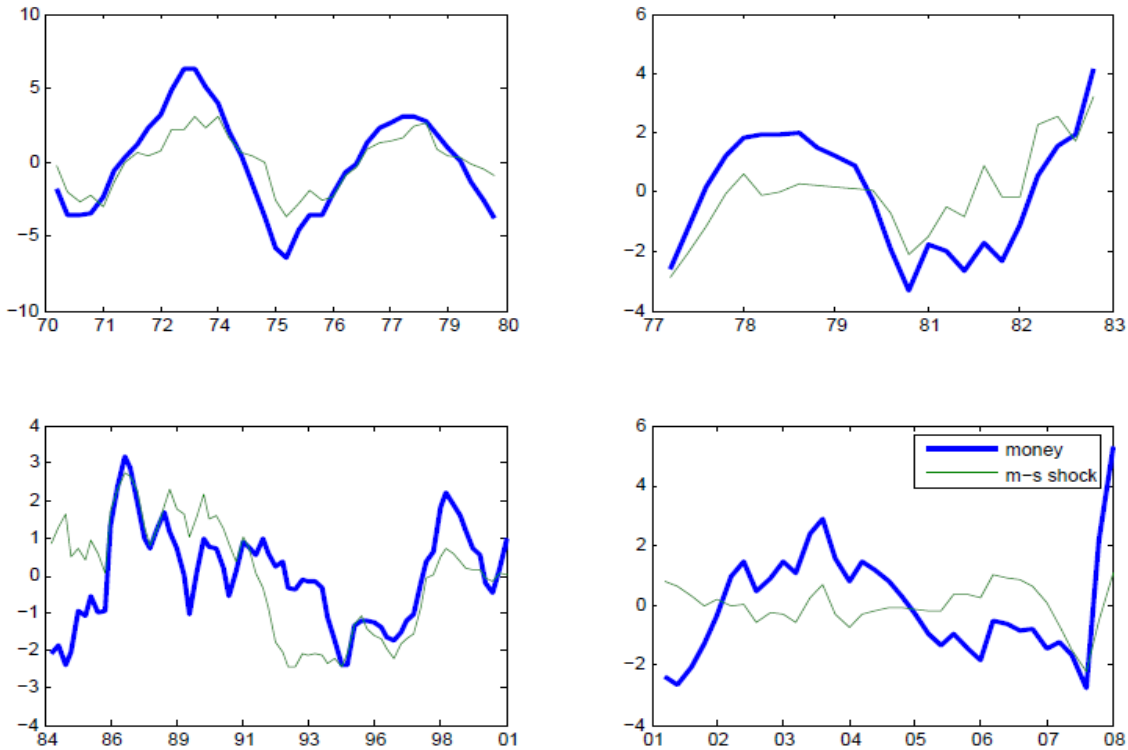

Figure 3

Interest Rates (Demeaned) and Money Supply shocks (Subsamples)

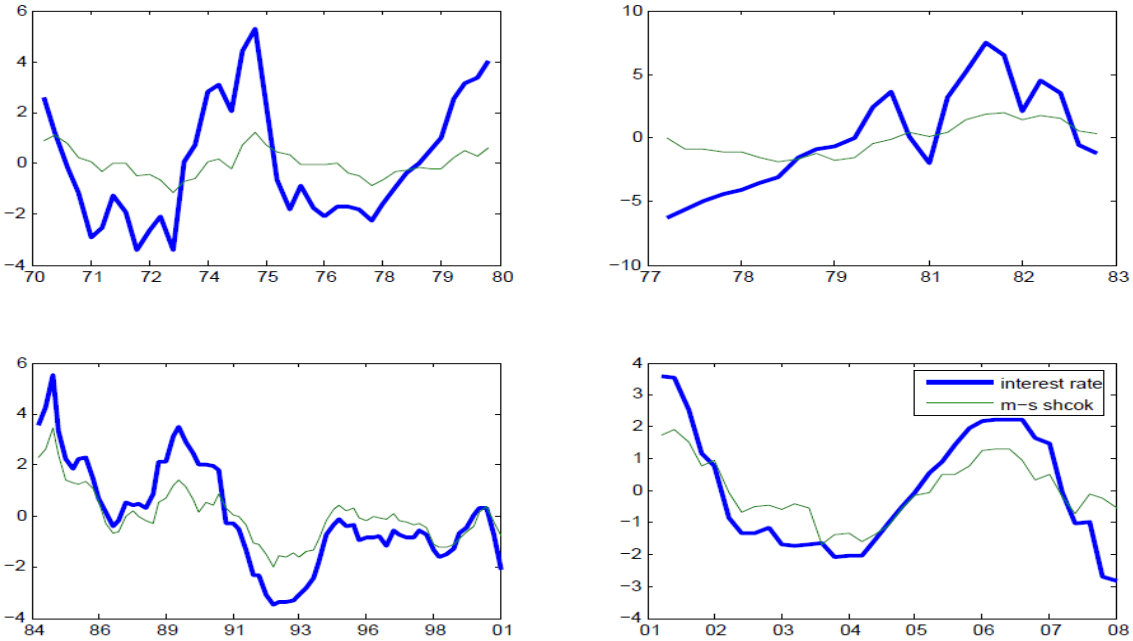

Figure 4

Money Supply (Detrended) and Money Supply shocks (Subsamples)

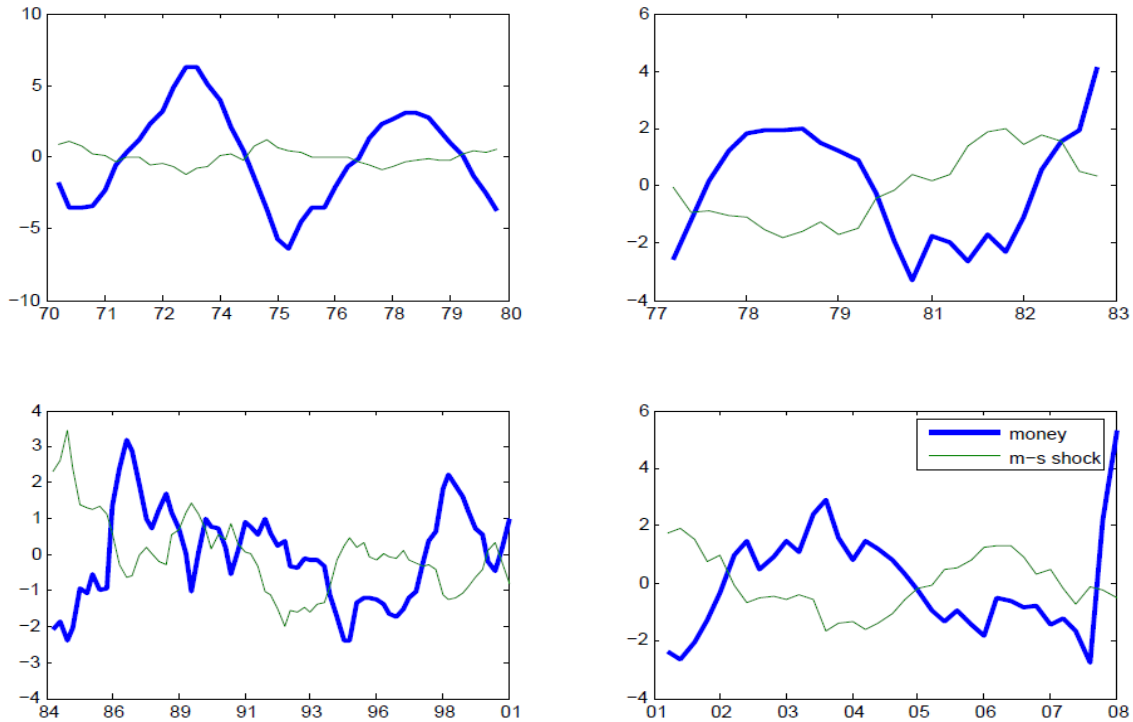

Figure 5

Impulse Response Functions

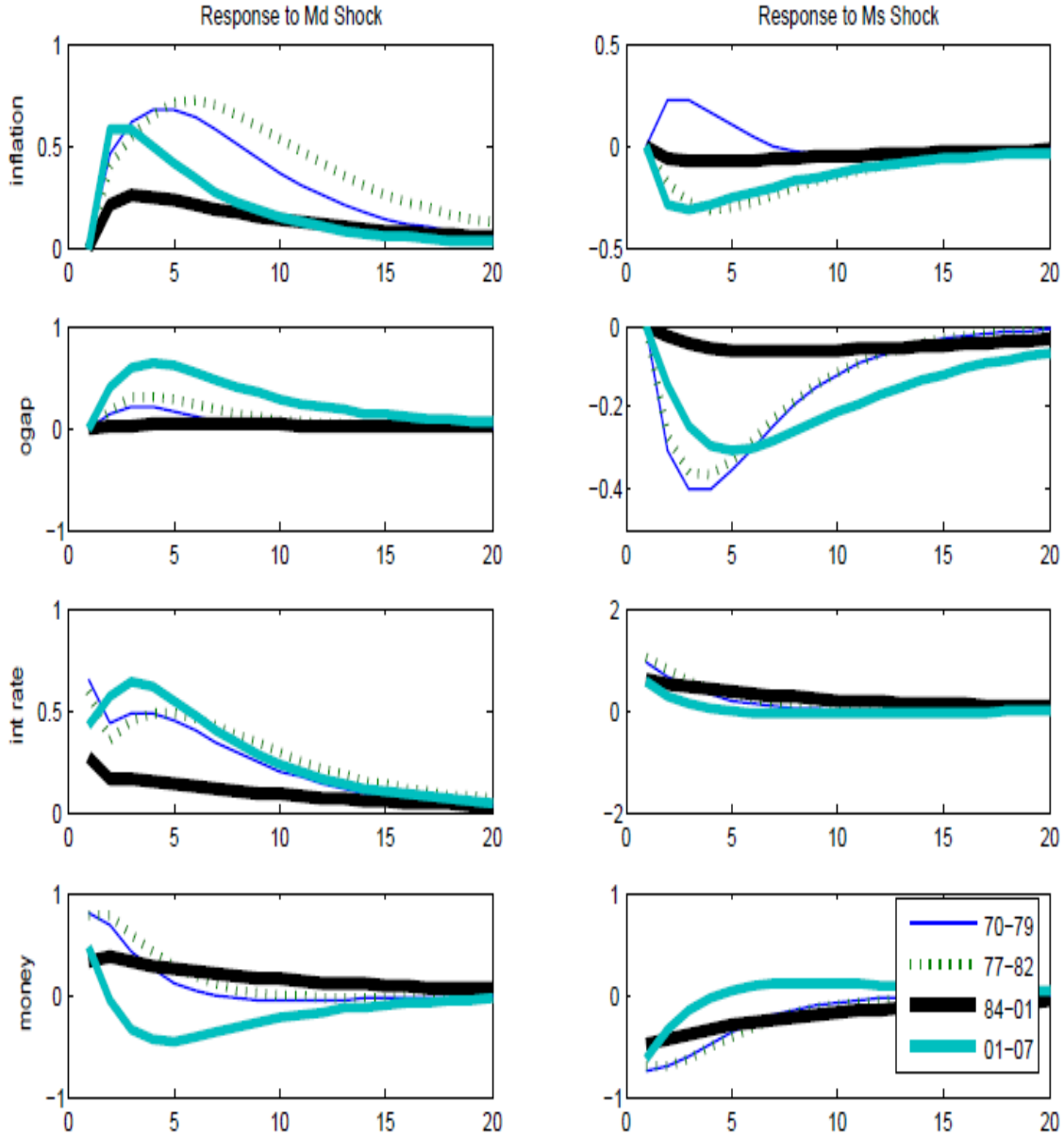

Figure 6

Macro Variables Before and After the Financial Crisis