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NOTE

A NOTE ON MONEY AND THE CONDUCT OF MONETARY POLICY

JAGJIT S. CHADHA
University of Kent

LUISA CORRADO
University of Rome, Tor Vergata
and
University of Cambridge

SEAN HOLLY
University of Cambridge

Prior to the financial crisis, mainstream monetary policy practice had become disconnected from money. We outline the basic rationale for this development using a simple model of money and credit in which we explore the conditions under which money matters directly for the conduct of policy. Then, using a DSGE model, we examine the circumstances under which money becomes more closely linked to inflation. We find that money matters when the variance of the supply of lending dominates productivity and the velocity of money demand. This is because amplifying the role of loans supply leads to an expansion in aggregate demand, via a compression of the external finance premium, which is inflationary. We consider a number of alternative monetary policy rules, and find that a rule which exploits the joint information from money and the external finance premium performs best.

Keywords: Money, Dynamic Stochastic General Equilibrium, Policy Rules, External Finance Premium

1. INTRODUCTION

The standard, mainstream macroeconomic model [Woodford (2003), Galí (2008)] has little, if any, independent role for the money supply. Money is endogenous

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and adjusts with movements in the demand for money. The use of the nominal short-term interest rate as the instrument of policy insulates the real economy from shocks to the money market. This insight goes back to Poole (1970), who showed that the use of the interest rate as the instrument of policy insulates the economy from shocks to the demand for money. More recently, Ireland (2000) has shown that Poole's result carries over to the New Keynesian model. This dichotomy would suggest that there will be little short-term relationship between changes in the stock of money and credit and output and inflation, even though in the long run the price level will rise in proportion to the stock of money. This paper contributes to this discussion by considering why and in what circumstances the monetary authorities should pay attention to the monetary aggregates.

Despite the clarity of this result in the mainstream theoretical model, there is conflicting empirical evidence on the role of money and credit in business cycles. For example, Reynard (2007) provides evidence to suggest that there is a systematic empirical relationship between movements in money and subsequent prices and output. Using data for the United States, the Euro area, and Switzerland, he finds that monetary developments provide information about subsequent inflation. Nelson (2002) also finds empirical evidence of a direct effect of base money on output. He argues that money may be acting as a proxy for various yields that affect aggregate demand. In contrast, Ireland (2004) provides a model in which empirical measures of real money balances must first be adjusted for shifts in money demand to isolate the effects of money on output and inflation. Even taking this into consideration, he finds that money plays a minor role in explaining the business cycle.[1]

Andres et al. (2006) examine the role of money using an estimated model of the Eurozone built on a dynamic equilibrium framework. They find that, first, consumption is not affected by money balances. Second, shocks to money demand can forecast real balances, but it requires real shocks to explain the bulk of fluctuations in prices, output, and interest rates. Favara and Giordani (2009) offer a direct evaluation of the contribution that money can make to explaining movements in inflation and output. Using a VAR, they find that shocks to monetary aggregates appear to have substantial and persistent effects on inflation, output and interest rates.

Benk et al. (2005) take a different approach: they construct a measure of credit shocks and find that the credit shocks play a role in explaining GDP. The credit shocks, it is argued, are the product of legislative changes in the regulation of banks in the United States. The mainstream view that narrow definitions of money (M0 and M1) do not appear to have significant real effects draws on the early work of Chari et al. (1995), who found that monetary aggregates covary mainly positively with output because money demand is primarily driven by aggregate shocks to the private economy. Christiano et al. (1999) find that shocks to money demand measured by narrow measures of money (M0 and M1) do not have significant real effects, whereas shocks to M2, which involve a measure of credit, has some significant real effects.

At first blush the different empirical results in the literature are difficult to reconcile. One obvious possibility is that over the sample periods being used,

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monetary policy was not always conducted strictly along the lines of the New Keynesian framework. There, as we have already noted, the role of the short-term interest rate is central. It is certainly true, for example, in the United Kingdom, that there were significant periods during which monetary aggregates were targeted, or else the exchange rate. A policy of explicit reliance upon the short-term nominal interest rate started only in 1992 with the formal adoption of inflation targeting. It may be that these alternative regimes impart a sufficient departure from the canonical New Keynesian model for effects of money to show up in the data. Moreover, the European Central Bank has always followed a two-pillar approach. The first pillar gives a prominent role to a "broadly based assessment of the outlook for future price developments" and the second pillar relies on a monetary analysis of trends.

But we are interested in explaining the results with reference to the prominence of shifts in the supply of bank credit.[2] The role of banks, other financial institutions, and the financial system, which provide loans and help determine asset prices—are often given particular prominence in discussions of the transmission mechanism of monetary policy.[3] And so a significant corpus of economists have not given up entirely on the idea that the monetary aggregates can sometimes contain information about the future state of the economy, as well as about the transmission mechanism of monetary policy.[4] To borrow an analogy from Kiyotaki and Moore (2001), "the flow of money and private securities through the economy is analogous to the flow of blood . . . money is the blood that dispatches resources in response to those (price) signals" (p. 5). More recently, and especially in the light of recent turbulence in world financial markets, economists have been reexamining the role that money, and more generally credit, can play independent of the policy rate. One avenue we explore in this paper is motivated by the role of money as a suppler of payment services to credit-constrained consumers. The price of such loans, as a premium above the policy rate, reflects the marginal cost to banks of their supply and so it responds to increases in the efficiency of supply relative to demand for loans. This relative price can move out of line with the policy rate set by the central bank when there are independent sources of fluctuations in the ability of banks to supply liquidity, for example, as a result of their efficiency in screening loans (monitoring) or the value of posted collateral.

The paper is structured as follows. In Section 2 we consider the role of money in a highly stylized macro model and show that, in accordance with the mainstream literature, shocks to money demand do not affect output and inflation. We then go on to consider a version of this model with credit, following Bernanke and Blinder (1988). There is an external finance premium (EFP), so that there is not always a one-to-one correspondence between the interest rate set by policy makers and that which lenders pay. In this case the monetary authorities cannot completely insulate the real economy from shocks in financial markets, compared to the situation in which only money demand shocks matter. This leads to a modification of the standard Taylor principle for the stability of the model under an interest rate rule. In particular, factors that determine the supply of loans can alter the

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appropriate policy response to inflation. To help to flesh out this insight with a more fully specified and micro-founded model, in Section 3, we reexamine the role of money for policy in the context of Goodfriend and McCallum's (2007) model, which adds a banking sector to a dynamic stochastic general equilibrium (DSGE) model.[5] This means that shocks in the financial sector that affect the external finance premium can now alter output and inflation. In Section 4, using an impulse-response analysis, we show that under an inflation-targeting policy, money and financial spreads become negatively correlated when shocks to the supply of bank loans dominate those to money demand or to productivity in the real economy. Section 5 explores the conditions under which money provides a reliable signal about inflation and output and considers a number of simple augmented rules to capture the signal. We observe that when supply shocks dominate in the money market, spreads and money move in opposite directions, and so one rule that has attractive properties is one that employs information about the difference in money and spreads. We show that such a rule is better able to stabilize the economy than a simple inflation-targeting rule when there are shocks to financial markets. Section 6 concludes and offers some directions for future work.

2. MONEY, CREDIT, AND INTEREST RATE RULES

In the first part of this section we take a stylized version of the New Keynesian (NK) model and show the standard result that as long as the policy rule satisfies the Taylor principle, output and inflation can be insulated from money demand shocks. In the second part we go on to reexamine this result in a NK version of Bernanke and Blinder's (1988) credit model, in which financial spreads also matter for the level of output. We now find that monetary policy also needs to be responsive to conditions in credit markets that we capture by the external finance premium [Meier and Müller (2005)] in order to stabilize output and inflation. First, consider a simple model of money demand (for which supply is implicitly perfectly elastic) appended to a standard NK framework [see King (2002)], which uses a monopolistically competitive supply side with Calvo price setting. In this simple setting, the stock of money is essentially decoupled and plays no role in the determination of output and inflation.

In the simple NK model,

$$y_t = E_t y_{t+1} - \sigma (R_t - E_t \pi_{t+1}) + \epsilon_{A,t}, \tag{1}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa (y_t - \tilde{y}_t) + \epsilon_{B,t}, \tag{2}$$

$$h_t - p_t = y_t - \theta R_t + \epsilon_{C,t}, \tag{3}$$

$$R_t = \phi_\pi \pi_t + \epsilon_{D,t}, \tag{4}$$

$$\tilde{y}_t = \epsilon_{E,t}, \tag{5}$$

$$\pi_t = \frac{1-\tau}{\tau} p_t, \tag{6}$$

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all variables are expressed as log deviations from steady state. Equation (1) gives aggregate demand, y_t, as a function of this period's expectation, E_t, of demand next period, y_{t+1}, and of the expected real interest, where R_t is the policy rate, $E_t\pi_{t+1}$ is the next period expectation of inflation, and σ is the intertemporal rate of substitution in output.[6] Equation (2) is the forward-looking NK Phillips curve that relates current inflation, π_t, to discounted expected next-period inflation, where β is the subjective discount factor, and is proportional to the deviation of aggregate demand from supply, where κ is the slope of the Phillips curve.[7] In equation (3), real balances, $h_t - p_t$, are held in proportion to demand, y_t, and inversely with the opportunity cost of holding non-interest-paying money, R_t, with semielasticity θ. Equation (4) is a simple interest-rate-based rule that is used to stabilize inflation about its steady-state value with the weight on inflation given by ϕ_π. The supply side of the economy, $\tilde{y}_t$, which we interpret as the flex-price level of output, is given by (5). Finally, τ is the fraction of firms that hold prices fixed, and so $(1-\tau)$ is the fraction that are given a signal to reprice as a markup over marginal costs; thus inflation in equation (6) is simply the ratio of firms that reprice at the new price level, p_t, to those that cannot reprice.

The system is subject to stochastic shocks, $\epsilon_{A,t}$, $\epsilon_{B,t}$, $\epsilon_{C,t}$, $\epsilon_{D,t}$, $\epsilon_{E,t}$, which are respectively to demand, mark-up, money markets, monetary policy, and aggregate supply. We can substitute (4) into (1) and (5) into (2) and solve (6) for p_t and substitute into (3) to give us a system of three difference equations that can be written in vector form, if we suppress the stochastic errors, as

$$E_t\mathbf{x}_{t+1} = \mathbf{\Lambda}\mathbf{x}_t, \tag{7}$$

where the transpose of the vector of state variables $\mathbf{x}_t$ is

$$\mathbf{x}_t' \equiv [\, y_t \quad \pi_t \quad h_t \,],$$

where $\mathbf{\Lambda}$ is a 3×3 matrix. The existence or not of a unique solution for $\mathbf{x}_t$, as is well understood, given the forcing processes, $\boldsymbol{\epsilon}_t$,[8] will depend upon matching the number of eigenvalues of the matrix $\mathbf{\Lambda}$ within the unit circle with the number of predetermined state variables. Typically the coefficients of the policy rule, (4), are set to ensure local determinacy.[9]

What concerns us here is the role, if any, that money, h_t, plays in this economy. We note that the matrix can be written in block form,

$$\mathbf{\Lambda} = \begin{bmatrix} \kappa\frac{\sigma}{\beta}+1 & \sigma\phi_\pi - \frac{\sigma}{\beta} & 0 \\ -\frac{\kappa}{\beta} & \frac{1}{\beta} & 0 \\ 1-\frac{\kappa}{\beta-\tau\beta}(\tau+\varkappa) & \sigma\phi_\pi + \frac{1}{\beta-\tau\beta}(\tau+\varkappa) & 0 \end{bmatrix}$$
$$= \begin{bmatrix} \mathbf{A} & \mathbf{0} \\ \mathbf{C} & \mathbf{D} \end{bmatrix},$$

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where $\varkappa = (\tau - 1)(\sigma + \theta\phi_\pi)$, A is 2×2, C is 1×2, D is a 1×1 null matrix, and 0 is a 2×1 null column vector. The block triangularity of $\mathbf{\Lambda}$ means that its eigenvalues are simply given by the eigenvalues of $\mathbf{A}$, referring to $[\pi_t \quad y_t]$, and $\mathbf{D}$, referring to $[h_t]$. Also, the determinacy of $\mathbf{\Lambda}$ follows from the determinacy of $\mathbf{A}$, given that $\mathbf{D}$ is a null matrix. In this case, with both inflation and output nonpredetermined, determinacy will require A to have two eigenvalues outside the unit circle and the trace $\mathrm{Tr}(A)$ to be positive. This requires $\mathrm{Det}(A) - \mathrm{Tr}(A) > -1$, for which a necessary and sufficient condition is that

$$\phi_\pi > 1, \tag{8}$$

which is the familiar condition that for stability real rates must increase (decrease) by more than any positive (negative) inflation shock. This solution is recursive in that as long as inflation and output are pinned down to a unique solution path, the money stock (and the price level) is (are) also determined in each period. In other words, there is no role here for the money stock to destabilize the economy independently. This is essentially the NK generalization of the Poole assignment. Using the short-term interest rate as the instrument of policy, the real sector can be insulated from shocks to the demand for money. Moreover, shocks to aggregate demand can also be offset completely [Galí (2008)].

We now consider how a primitive banking sector can be introduced into the NK model using the approach of Bernanke and Blinder (1988). Aggregate demand in

$$y_t = E_t y_{t+1} - \sigma\left(R_t^m - E_t\pi_{t+1}\right) + \epsilon_{A,t}. \tag{1'}$$

now depends on the interest rate on loans in the credit market, R_t^m, rather than directly on the policy rate, R_t, for which we will now solve equation (1′). The Phillips curve is (2) as before. So the interest rate on loans is determined by market clearing, for which we will now solve. The real supply of loans by banks, $l_t^s - p_t$, depends positively on the external finance premium $(R_t^m - R_t)$ and on (real) bank deposits, $(d_t - p_t)$, where γ_c can be interpreted as a measure of the extent of leverage of loans over deposits, whereas the costs of monitoring or the availability of collateral would be reflected in α_c:

$$l_t^s - p_t = \alpha_c\left(R_t^m - R_t\right) + \gamma_c(d_t - p_t) + \epsilon_{ms,t}. \tag{9}$$

We now turn to the real demand for loans, $l_t^d - p_t$, which depends negatively on the external finance premium,

$$l_t^d - p_t = -\theta_c\left(R_t^m - R_t\right) + \epsilon_{md,t}. \tag{10}$$

Bank deposits, replacing money demand in (3), are held to finance output:

$$(d_t - p_t) = y_t. \tag{3'}$$

Equating $l_t^s = l_t^d$ and suppressing stochastic terms, we can solve for the market interest rate in terms of the policy rate, which is set by (4), and the parameters of

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loan supply:

$$R_t^m = R_t - \frac{\gamma_c}{\alpha_c + \theta_c} y_t = R_t - \lambda_c y_t. \tag{11}$$

Solving for the equilibrium in the market for loans, and using the policy rule in (4), we can reduce the model to the two-equation system

$$E_t y_{t+1} + \sigma E_t \pi_{t+1} = y_t (1 - \sigma \lambda_c) + \sigma \phi_\pi \pi_t, \tag{12}$$

$$\beta E_t \pi_{t+1} = -\kappa (y_t - \widetilde{y}_t) + \pi_t, \tag{13}$$

where $\lambda_c = \frac{\gamma_c}{\alpha_c + \theta_c}$. The necessary and sufficient condition for the stability of this model is now

$$\phi_\pi > 1 + \lambda_c \frac{(1-\beta)}{\kappa}. \tag{14}$$

In contrast to the standard NK model, the policy maker needs to be more responsive to inflation in order to offset the effect of developments in credit markets, and more so when banks increase their loan supply relative to their deposit base. Hence the new condition (14) tells us that if money (or credit) is provided at an interest rate that differs from the policy rate, R_t, which itself varies with the costs of monitoring and the availability of collateral (or with the extent of leverage in the banking sector), the policy maker has to offset that spread as well as ensuring that the policy rate increases or decreases the real rate. In other words, the price at which money is supplied by the banking system might matter. The model examined in the following section gives us a micro-founded route to the result here and starts to fill in the missing arguments of a typical NK model by suggesting that money/credit affects both aggregate demand and policy.

3. A GENERAL EQUILIBRIUM MONETARY MODEL WITH BANKING AND CREDIT

As pointed out by Goodhart (2007) and by Kiyotaki and Moore (2001), money (aggregates) should be be made to mattter in general equilibrium models, as they affect the consumption decisions of liquidity-constrained households and the spreads across several financial instruments and assets. And as Woodford (2007) states, “money matters” in such circumstances, as it may be the root of disequilibrium and instability in the economy originating from the financial sector. A way to incorporate money and financial spreads into a general equilibrium setting is to study the banking sector proposed by Goodfriend and McCallum (2007; GM hereafter).[10] The main feature of the model is the inclusion of a banking sector alongside households, production, and the monetary authority. The model by GM complements the traditional accelerator effect [Bernanke et al. (1999)] with an attenuator effect, which is present in the model because monitoring effort is drawn into the banking sector in response to the expansion of consumption, which is accompanied by an expansion of bank lending that raises the marginal cost of loans and the external finance premium.

The main feature of this model is the underpinning of households, production, and the monetary authority with a banking sector. Households, which are liquidity-constrained, decide the amount of consumption and the amount of labor they wish to supply to the goods production sector and to the banking sector. They also demand deposits, money (liquidity), as a function of the amount of consumption they wish to finance. The production sector is standard [Yun (1996)], characterized by monopolistic competition and Calvo pricing, with a Cobb–Douglas production function, subject to productivity shocks. Profit-maximizing firms decide the amount of production they wish to supply and the demand for labor. By clearing the household and production sectors, we can define the equilibrium in the labor market and in the goods market. These two sectors also provide the standard relationship for the riskless interest rate and the bond rate.

Finally, the banking sector matches deposit demand from liquidity-constrained consumers with a loan-producing technology. Specifically, banks substitute monitoring work for collateral in supplying loans. More monitoring is achieved by increasing the number of people employed in the banking sector and therefore reducing employment in the goods production sector. A fractional reserve requirement with a fixed reserve-deposit ratio is assumed. Given this technology, banks decide on the amounts of loans they can supply and the amount of monitoring required. At the same time, households' consumption is affected by the availability of loanable funds. The Appendix lists all the model equations.

3.1. Consumption and Collateral

We can summarize the relationship for consumers in the GM framework around an equilibrium steady state c in the reduced form (subscript t denotes deviations from steady state and variables with no subscript are steady-state parameters):[11]

$$c_t = \left\{ v_t c + (1-\alpha)(m_t + a2_t) + \alpha \left[\frac{b}{b+k_1} b_t + \frac{k_1}{b+k_1}(q_t + a3_t) \right] \right\} \times \left(\frac{b+k_1}{b(1-\alpha)+k_1} \right). \quad (15)$$

With the presence of a cash-in-advance constraint, a shock to velocity, v_t, will increase consumption. Consumption, c_t, is also positively affected by the amount of monitoring work, m_t, where α is the share of collateral in the loans production function and $(1-\alpha)$ represents the share of monitoring costs. It is also affected by the amount of collateral represented by bonds, b_t, and capital, whose value is given by q_t. A positive shock to monitoring, $a2_t$, by increasing the efficiency with which banks produce loans, increases the supply of loans and therefore consumption. Similarly, a negative shock to collateral, $a3_t$, by reducing the price of capital, q_t, will negatively affect consumption. The parameters c, b, and k_1 represent the steady-state fraction of consumption in output, the holding of bonds, and a composite parameter reflecting the inferiority of capital compared to bonds

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as liquidity.[12] The demand for monitoring work is given by

$$m_t = -w_t - \frac{(1-\alpha)c}{mw}\left(c_t + \frac{\phi}{\lambda}\lambda_t\right). \quad \textbf{(16)}$$

A higher wage, w_t, will reduce the resources devoted to monitoring. Similarly, monitoring will be affected by the marginal utility of consumption and the marginal value of households' funds, λ_t. The steady-state parameters, m, w, and $\frac{\phi}{\lambda}$, represent the steady-state proportion of employment in the banking sector, the level of the real wage, and the ratio of the weight of consumption in the utility function relative to the steady-state shadow value of consumption.

With a banking sector of this type in the model, we can link money and asset prices directly to output and inflation, because consumption, which accounts for most of the fluctuations in output in this model, is closely dependent on money market perturbations, the development of banking technology, and asset prices outcomes. Now money and lending affect consumption and the level of economic activity and will also have implications for asset prices.

A key term here is the marginal value of collateralized lending, Ω_t, which increases as consumption rises and falls as collateral becomes more widely available:

$$\Omega_t = \frac{k_2}{b+k_2}\left(c_t - q_t - a3_t\right) - \frac{b}{b+k_2}b_t. \quad \textbf{(17)}$$

Ω_t depends on the value of the collateral, q_t and b_t, any collateral shock, $a3_t$, and on consumption, c_t. Higher levels of consumption increase the marginal value of capital. The increase in collateral value leads to more borrowing and more consumption. The parameter k_2 is again a composite coefficient similar to k_1.[13]

The marginal value of collateralized lending also feeds back into the capital asset price equation,

$$q_t = (\delta_1 + \gamma_1)\left(E_t\lambda_{t+1} - \lambda_t\right) + \delta_1 E_t q_{t+1} - \frac{k\Omega\phi}{c\lambda}\left(c_t + \lambda_t\right)$$
$$+ k\Omega\left(\frac{\phi}{c\lambda} - 1\right)\left(\Omega_t + a3_t\right) + \gamma_1 E_t\left[\mathrm{mc}_{t+1} + (1-\eta)\left(n_{t+1} + a1_{t+1}\right)\right]. \quad \textbf{(18)}$$

In (18) the marginal value of collateralized lending, Ω_t, potentially can amplify asset price volatility and magnify the response of the economy to both real and financial shocks. Both real shocks, $a1$, and financial shocks, $a3$, feed back directly into asset prices alongside the expected marginal productivity of capital $[\mathrm{mc}_{t+1} + (1-\eta)(n_{t+1} + a1_{t+1})]$, where mc_{t+1} denotes marginal cost in period $t+1$, η is the share of capital in the goods production function, and n is employment in the goods production sector. Similarly, expected asset prices, $E_t q_{t+1}$, and the change in the shadow value of households' funds, $(E_t\lambda_{t+1} - \lambda_t)$, alongside the wedge between the marginal utility of consumption and the shadow value of funds, also affect the value of capital, q_t. The parameter δ_1 is a composite function of the depreciation rate of capital, whereas the parameter γ_1 is a composite function of

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steady-state marginal costs, of steady-state employment in the goods sector, and of the capital share in the production of goods.[14]

3.2. Interest Rate Spreads

The last building block involves the determination of interest rate spreads. The benchmark theoretical interest rate R^T is simply a standard intertemporal nominal pricing kernel, priced off real consumption and inflation. It can be written as a one-period Fisher equation:

$$R_t^T = E_t(\lambda_t - \lambda_{t+1}) + E_t\pi_{t+1}. \tag{19}$$

The difference between the interbank rate R and R^T is the external finance premium, which is the premium paid by the private sector for loans:

$$R_t^L - R_t = \underbrace{[v_t + w_t + m_t - c_t]}_{\text{EFP}_t}. \tag{20}$$

The external finance premium, EFP_t, is the real marginal cost of loan management, and it is increasing in velocity, v_t, real wages, w_t, and monitoring work in the banking sector, m_t, and decreasing in consumption, c_t.[15] The external finance premium is also dependent on the share of collateral costs in loan costs (α) and reserve requirements (rr), but as these two parameters are both constant in this model, they do not appear in the log-linearization.

The yield on government bonds is the benchmark rate, R^T, minus the liquidity service on bonds,

$$R^B R_t^B = R^T R_t^T + \left[\frac{\phi\Omega}{c\lambda}(c_t + \lambda_t) - \left(\frac{\phi}{c\lambda} - 1\right)\Omega\Omega_t\right], \tag{21}$$

where $(c_t + \lambda_t)$ measures the household's marginal utility relative to the household's shadow value of funds, whereas Ω is the marginal value of the collateral. In the model these key margins—the real marginal cost of loan management versus the liquidity service yield—determine the behavior of spreads.

Finally, the monetary authorities, who set the interbank lending rate, are assumed to follow a simple inflation-targeting rule in the first instance:

$$R_t = \phi_\pi \pi_t + \epsilon_t. \tag{22}$$

In this section we have outlined, briefly, the key elements of the GM model and explained how it links output explicitly to developments in the monetary sector and how the interaction between those sectors determines financial spreads. In the following section we analyze the key responses of the model to a series of shocks and try to infer from this what is the relationship between money and inflation, and what role financial spreads play.

4. MODEL RESULTS

The model is solved using the solution methods of King and Watson (1998), who also provide routines to derive the impulse responses of the endogenous variables to different shocks, to obtain asymptotic variance and covariances and to simulate the data. The simulation is carried out by running a random number generator in Matlab. Following a fixed random seed, we generate a set of normally distributed exogenous shocks of length K =10,000. These random shocks are fed into the recursive law of motion of key variables, for which see the Technical Appendix. For the impulse-response analysis and simulation exercise we examine the effects of real and financial shocks described in Table A.3. We also report the choice of moments for the forcing variables. These are standard parameters in the literature.

4.1. Calibration

Following Goodfriend and McCallum (2007) we choose the consumption weight in utility, ϕ, to give one-third of available time in either goods or banking services production.[16] We also set the relative share of capital and labor in goods production η to be 0.36. We choose the elasticity of substitution of differentiated goods, θ, to be equal to 11. The discount factor, β, is set to 0.99. which is the canonical quarterly value, whereas the mark-up coefficient in the Phillips curve, κ, is set to 0.05. The depreciation rate, δ, is set to be equal to 0.025, whereas the trend growth rate, γ, is set to 0.005, which corresponds to 2% per year. The steady-state value of the ratio of bond holdings to GDP, b, is set to 0.56 as of the third quarter of 2005.

The parameters linked to money and banking are defined as follows. Velocity at its steady-state level is defined as the ratio of U.S. GDP to M3 as of the fourth quarter of 2005, yielding 0.31. The fractional reserve requirement, rr, is set at 0.005, measured as the ratio of U.S. bank reserves to M3 as of the fourth quarter 2005. The fraction of collateral, α, in loan production is set to 0.65, the coefficient reflecting the inferiority of capital as collateral, k, is set to 0.2, and the production coefficient of loans, F, is set to 9. The low value of capital productivity reflects the fact that usually banks use a higher fraction of monitoring services and rely less on capital as collateral. Turning to the parameters in the various policy rules,[17] we set the coefficient on inflation with inflation targeting, ϕ_π^T, to be equal to 50, as in GM, in order to reflect a strong response to inflation and a smoothing parameter, ρ, equal to 0.8; the coefficient on inflation with a Taylor rule, ϕ_π, is set to 1.5, whereas the coefficient on output, ϕ_y, is set to 0.5 as in GM. For the rule that responds to asset prices we assume a coefficient on asset price growth, ϕ_q, equal to 0.5.

4.2. Implied Steady States

With these parameter values we see that the steady state of labor input, n, is 0.31, which is close to one-third, as required. The ratio of time working in the banking service sector, $\frac{m}{m+n}$, is 1.9% under the benchmark calibration, not far from 1.6%, the share of total U.S. employment in depository credit intermediation as of August 2005. As the steady states are computed at zero inflation, we can interpret all the rates as real rates. The riskless rate, R^T, is 6% per annum. The policy rate, R, is 0.84% per annum, which is close to the 1% per year average short-term real rate [see Campbell (1999)]. The government bond rate, R^B, is 2.1% per annum. Finally, the collateralized external finance premium, $R^L - R$, is around 2% per annum, which is in line with the average spread of the prime rate over the federal funds rate in the United States.[18]

4.3. Examining the Role of Money in This Economy

In this section we describe, briefly, the effects of a series of shocks to productivity and velocity and of two types of shocks to the financial sector.[19] As is implied by Section 2, the dynamics of the model suggests that a key role is played by the loan rate, the external finance premium and policy rate, as a regulator of demand. For example, any shock that raises collateral value will increase the supply of loans. At the same time, the collateral shock will increase the demand for deposits and therefore the amount of monitoring work that needs to be carried out by banks. So the increase in the amount of employment in monitoring work will increase the real marginal cost of the management of loans, and so the positive effect of higher collateral will be attenuated. What we try to do here is simply assess the impact of some key driving forces, both on the quantity of money in this model and also on the external finance premium at which that money is supplied.

Goods productivity. A shock, $a1$, to goods productivity,[20] under the inflation-targeting rule, can be stabilized. Hence hours worked in the goods production sector, n, and the benchmark rate, R^T, are almost invariant to the shock.[21] However, c, w, q, and m are all higher. In fact, with hours worked in goods production relatively stable, increased productivity shows up as higher consumption c and higher real wages w. Also, increases in q reflect a higher marginal product of capital. The increase in monitoring hours m reflects the increased demand for and supply of deposits. The combined effect is to increase the EFP. But the movement of money (deposits/loans) in the same direction as the external finance premium implies that money would be a poor indicator of financial conditions, as the increase in money does not imply that there has been an inflationary monetary expansion.

Banking productivity. Again, under an inflation-targeting rule, a shock to banking productivity, $a2$ is stabilized and therefore so is the benchmark interest rate. Because of higher banking productivity, monitoring hours, m, decline, whereas there is little effect on the value of collateral q, on consumption c and on real wages w. The combined effect, by reducing the marginal costs of loan supply, is to decrease the EFP. In this case, therefore, money might indicate some loosening of financial conditions.

Collateral prices. Under inflation targeting, a positive shock to collateral, $a3$, leads to stable inflation and benchmark interest rate, R^T. There are small increases in c and w. As we have a positive shock to collateral, there is a fall in monitoring hours, m, which dominates the costs of loans supply. The overall effect in general equilibrium is to reduce the EFP, alongside an increase in the quantity of money. In these circumstances, the increase in money is associated with some loosening of financial conditions.

Money velocity. With an inflation-targeting rule, a positive shock to velocity v increases c, w, n, and inflation. Because the capital/labor ratio is lower, the price of capital q rises, whereas hours of monitoring, m, decrease as the existing stock of money works harder. The joint effect is a decrease in the EFP and a fall in the money supply.[22] In this case, as with the productivity shock, money does not turn out to be a good indicator of inflationary pressure.

The information content of money. Overall we find that money plays a crucial role in driving the EFP when the banking sector itself is the source of the shock (i.e., monitoring efficiency and/or collateral shocks), with banks becoming more or less able to supply a given quantity of loans. It is this independent source of supply shocks to the loanable funds market that drives the EFP in the direction opposite to that of the quantity of loans and so can act to compress (unwind) yields when liquidity becomes abundant (scarce).

We can examine the information content of money more formally in the GM model by examining some properties of the simulated data. We can simulate the model under the benchmark case, and for illustrative purposes we can also raise the standard deviation of $a2$ and $a3$ shocks from 1 to 5% to examine what happens when such shocks are dominant. Table 1—for the benchmark shocks and banking dominant shocks—shows, on the left-hand side of the table, the lead, contemporaneous, and lagged correlations between money and inflation and output from HP filtered simulations. The main difference in the two cases is that when banking shocks dominate, money has positive rather than negative lead information for inflation. Following King (2002), the final two columns show the sum of contemporaneous money and four lags of money in a regression of inflation and of output on lags of inflation, output, and money. We can see that money has significant information for inflation in both cases, but when banking shocks are dominant, money has positive information, in the sense that positive money growth leads to higher inflation. It would therefore seem appropriate for central banks to place emphasis on monetary aggregates when banking sector or loans supply shocks dominate.

TABLE 1. The information content of money for output and inflation: Robust regressions on simulated data

	$t-4$	$t-3$	$t-2$	$t-1$	$t=0$	$t+1$	$t+2$	$t+3$	$t+4$	$\sum$	F
					Inflation						
Benchmark	−0.03	−0.08	−0.16	−0.31	−0.60	−0.23	−0.05	0.06	0.11	−0.03	25.3**
Banks dominant	−0.22	−0.16	−0.06	0.06	0.20	0.29	0.32	0.32	0.30	0.05	3.7*
					Output						
Benchmark	0.03	0.15	0.30	0.49	0.69	0.45	0.25	0.09	−0.03	1.23	93.1**
Banks dominant	−0.06	0.06	0.21	0.42	0.66	0.49	0.32	0.19	0.09	1.19	116.6**

Note: The first two rows show the lagged, contemporaneous, and lead correlations between money and inflation for the benchmark shocks and for the "banking shocks dominate" case. Rows three and four report the same for output. An HP filter with $\lambda = 1,600$ is used. The final two columns sum the coefficients on money from a regression of inflation on lags of itself and current and lagged terms in money and output, as in King (2002), and the F-tests for joint significance of the coefficients using White heteroskedastic consistent standard errors from 500 random draws from the initial simulation of 10,000.

5. RECONSIDERING SIMPLE POLICY RULES

The previous section has shown that monetary and financial conditions might well matter when monetary policy is being set, over and above the policy rate. We concentrate on comparing shocks to the supply of banks loans involving collateral or monitoring costs. Note that a negative shock to the financial system originating in a rise in the cost of monitoring loans or a reduction in the collateral of borrowers has a opposite-signed impact on money and on the external finance premium—in this case money will contract and the spread widen. This suggests that the information on the spread and money might be used to inform monetary policy; that is, as well as reacting to inflation directly, the central bank can also respond to the spread.

Before considering this point in detail, we assess the effectiveness of the various policy rules proposed by Gilchrist and Saito (2008). We use the following rules for comparison.

Targeting Rule.

$$R_t = \phi_\pi^T \pi_t + \epsilon_t. \tag{23}$$

The policy rate is set by a feedback rule responding to inflation, π_t, with parameters, ϕ_π^T, where we assume that the policy maker targets zero percent inflation.

Money Rule. We also consider an alternative rule where the central bank controls the growth of high-powered money:

$$\Delta h_t = \rho^H \Delta h_{t-1} + \epsilon_t, \tag{24}$$

where $h_t = \log(H_t)$ and Δh_t denotes the growth rate of H_t. In (24) we assume that $0 <| \rho^H |< 1$, whereas ϵ_t is the random component of policy behavior.

Taylor Rule with Inflation and Output. We assume, as in GM, an alternative rule where policy makers respond to output, y_t, and inflation, π_t, while also smoothing interest rates:

$$R_t = \rho R_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_y y_t) + \epsilon_t, \tag{25}$$

with $0 < \rho < 1$. In contrast to the inflation-targeting rule (23), where the policy maker targets zero inflation, the weight on inflation, ϕ_π, is lower at 1.5.

Policy Rule with Asset Price Growth. We also consider, as in Gilchrist and Saito (2008), an alternative formulation of (25) where the policy maker responds to the growth rate of observed asset prices, Δq_t:

$$R_t = \rho R_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_q \Delta q_t) + \epsilon_t. \tag{26}$$

Augmented Rule. As an illustration of how policy makers might seek to respond directly to supply side shocks to the supply of loans—as suggested by equation (14)—we now assume that the monetary authority augments its inflation-targeting rule with a term in the difference between the external finance premium and money to capture the impact of the supply of money:

$$R_t = \phi_\pi^T \pi_t + \phi_m (h_t - \text{EFP}_t) + \epsilon_t, \tag{27}$$

where h is money and EFP is the external finance premium. In this case, when there is a demand shock, h_t and EFP_t will move in the same direction and the augmented rule will have the same effect as an inflation-targeting rule. But when the shock is to the supply of loans, money and the external finance premium will move in opposite directions, thereby altering the interest rate set by the monetary authority.

In the next section we assess the policy outcomes in terms both of the volatility of output and inflation and of a welfare approximation of the representative household from the implementation of a rule that targets zero inflation versus alternative rules that respond to aggregate demand, money, asset prices and the augmented rule. The welfare analysis will allow us to better understand how the policy maker should respond when banking shocks dominate.

5.1. Welfare Analysis

We first consider a welfare criterion often used to assess policy alternatives that depends only on the variance of output and inflation [e.g., Galí (2008)] and employs a standard loss function:

$$L_t^s = \frac{1}{2}\sigma_\pi^2 + \frac{1}{2}\sigma_y^2. \tag{28}$$

Given the primitive utility function of the GM model, we also trace out the direct welfare consequences for the representative household. The use of the approximation allows us to quantify precisely the welfare rankings arising from each of our policy rules, possibly allowing some normative statements. We derive a quadratic loss function using a second-order Taylor approximation to utility by using the labor demand function, marginal cost function, and sales-production constraint to substitute for household consumption.[23] Once reordered and simplified, we are left with a loss function with relevant terms in the variances of consumption, inflation, wages, employment in the goods sector, and the marginal cost:[24]

$$U_t - U = -\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t L_t + \mathcal{O}^3, \quad \mathbf{(29)}$$

$$\text{with } L_t = \frac{1}{2}\left[\begin{array}{c} \sigma_c^2 + \frac{\theta}{\chi(1-\eta)}\left(\frac{n}{c} - \frac{w}{c}\right)\sigma_\pi^2 - \\ \frac{w}{c}\sigma_w^2 - \frac{n}{c}\sigma_n^2 + \frac{\text{mc}}{c}\sigma_{\text{mc}}^2 \end{array}\right],$$

where $\chi = \frac{(1-\theta)(1-\beta\theta)}{\theta}\frac{1-\eta}{1+\eta(\theta-1)}$.

In the next section we will evaluate each policy rule under standard loss function (28) and the welfare approximation (29) when the standard deviation of the financial shocks rises.

5.2. Policy Experiment

Using both the welfare criteria, we can calculate the loss under each policy rule when we increase the standard deviation of banking shocks and then rank them using the metric laid out by Gilchrist and Saito (2008):

$$\text{Gain}(x) = \frac{L(\text{Least Stabilizing Policy}) - L(\text{Rule } x)}{L(\text{Least Stabilizing Policy}) - L(\text{Most Stabilizing Policy})}. \quad \mathbf{(30)}$$

The gain is defined as the difference between the loss, L, obtained from pursuing the policy rule x versus the less stabilizing rule (the asset rule), divided by the difference between outcomes obtained from pursuing the more stabilizing rule (the augmented rule), versus the asset rule. Doing so enables us to summarize the result of our policy comparison: if the relative gain is above (below) one, the policy in question is better (worse) than the augmented rule. If it is negative than the given policy actually performs worse than the benchmark. In Table 2 we can see that as we increase the size of banking shocks the asset-price rule performs worst relative to the augmented rule because it does not distinguish between demand- or supply-shock-driven changes in asset price. In contrast, the gain from a money rule rises, and although it is inferior to the augmented rule over the range we report, it is approaching the augmented rule when shocks to the supply side of the banking sector are particularly large relative to productivity and velocity shocks.[25]

Focusing on the augmented rule, we now trace out the effect on the policy losses of a steadily rising ratio of financial (monitoring, σ_{mon}, and collateral, σ_{col}) to real and monetary shocks in the model outlined in Section 3. The exercise here is to vary the ratio of the standard deviation of financial to real and monetary shocks,

TABLE 2. Relative gains

	S.D. of banking shocks				
	1%	2%	3%	4%	5%
	Welfare approximation				
Augmented	1	1	1	1	1
Taylor	0.987	0.985	0.983	0.982	0.982
Money	0.822	0.903	0.934	0.950	0.960
Targeting	0.459	0.477	0.481	0.482	0.483
Asset	0	0	0	0	0
	Standard loss function				
Augmented	1	1	1	1	1
Taylor	0.995	0.990	0.989	0.989	0.988
Money	0.862	0.934	0.957	0.970	0.976
Targeting	0.508	0.471	0.456	0.447	0.442
Asset	0	0	0	0	0

Notes: The relative gain $\text{Gain}(x) = \frac{L(\text{Asset Rule}) - L(\text{Rule } x)}{L(\text{Asset Rule}) - L(\text{Augmented Rule})}$ is defined as the loss from the welfare approximation, L, obtained from pursuing the policy rule x versus the least stabilizing rule (the asset rule), divided by the difference between outcomes obtained from pursuing the most stabilizing rule (the augmented rule) versus the least stabilizing rule (the asset rule).

Φ_m, defined as

$$\Phi_m : \frac{\sigma_{\text{mon}} + \sigma_{\text{col}}}{\sigma_{\text{prod}} + \sigma_{\text{vel}} + \sigma_{\text{mrk}} + \sigma_{\text{mp}} + \sigma_{\text{gov}}}. \quad \textbf{(31)}$$

In Figure 1 we vary on the x-axis the loading ϕ_m on the spread in the augmented rule, holding the relative standard deviation of the shocks fixed,[26] and report the loss given by the welfare approximation (29).

We note that the loss, L, is initially declining in ϕ_m. And so it seems clear that over some range, when financial shocks are dominant, inflation can be better stabilized. For this illustrative calculation the loss is minimized at around $\phi_m = 1$.[27] This simulation echoes the analytical result in Section 2, equation (14), which shows how the policy rule needs to offset those factors that might increase the external finance premium. In this simulation at least, the central bank best achieves the stabilization of inflation by exactly offsetting any narrowing or widening of the spread between the external finance premium and money.

5.3. Money under Alternative Rules

The correlations between inflation, money, and the EFP are tabulated for the two different policy rules in Table 3. Along the diagonals we show the standard deviation of money, inflation, and the EFP for the benchmark simulation and for the "banking shocks dominant" simulation. In the benchmark case the standard deviations of money and EFP are not altered greatly by the augmented rule,

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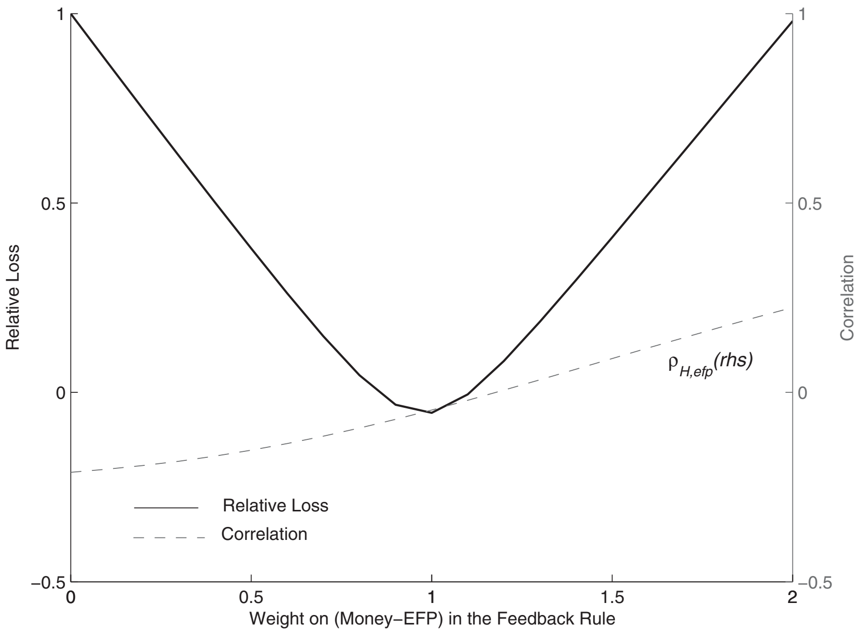

FIGURE 1. Optimal weight on money and EFP in augmented policy rule. On the x-axis we vary the weight on the augmented term in the feedback rule, money minus the external finance premium, when banking shocks are dominant, by setting the standard deviation of the banking shocks to 0.05 and fixing the standard deviations of the real and monetary shocks to their benchmark values as in Table 3. On the y-axis we report the welfare approximation $L_t = \frac{1}{2}[\sigma_c^2 + \frac{\theta}{\chi(1-\eta)}(\frac{n}{c} - \frac{w}{c})\sigma_\pi^2 - \frac{w}{c}\sigma_w^2 - \frac{n}{c}\sigma_n^2 + \frac{\mathrm{mc}}{c}\sigma_{\mathrm{mc}}^2]$, which is computed as a loss relative to the inflation-targeting case (zero weight on Money-EFP).

suggesting that the augmented rule does not help stabilize the economy over and above a simple rule. However, when banking shocks dominate, the correlation between money and inflation becomes positive and the correlation between the external finance premium and money becomes negative. But when with bank dominant shocks the augmented rule is adopted, the correlation between money and inflation is once more negative and the correlation between money and the EFP very small, as interest rates respond to money growth and to the EFP. Under the augmented rule, with a predominance of banking shocks, the volatility of money and particularly inflation is reduced compared to the inflation-only rule.

We treat the evidence here as illustrative of the extent to which an augmented rule of this type, which accounts for the joint information from money and financial spreads, may help stabilize a monetary economy. The identification of this information involves the simple insight that money growth and financial spreads will move in opposite directions under supply shocks to financial markets and, provided a suitable measure of money (or liquidity) and a constellation of financial spreads

TABLE 3. Correlation between money, inflation, and the EFP

Simple inflation-targeting policy rule

	Benchmark shocks				Banking shocks dominant			
	D_t	π_t	c_t	EFP_t	D_t	π_t	c_t	EFP_t
D_t	1.34%	−0.59	0.69	0.59	1.63%	0.20	0.66	−0.21
π_t		0.06%	−0.35	−0.97		0.22%	0.27	−1.00
c_t			1.14%	0.30			1.2%	−0.29
EFP_t				2.98%				10.89%

Augmented policy rule

	Benchmark shocks				Banking shocks dominant			
	D_t	π_t	c_t	EFP_t	D_t	π_t	c_t	EFP_t
D_t	1.37%	−0.88	0.71	0.64	1.41%	−0.89	0.72	−0.046
π_t		0.03%	−0.69	−0.56		0.03%	−0.70	0.023
c_t			1.13%	0.34			1.18%	−0.17
EFP_t				3.05				11%

Note: The table reports standard deviations along the diagonals and correlations in the upper of-diagonal cells. D_t denotes deposits, π_t is inflation, c_t is consumption, and EFP_t is the external finance premium. Variables are taken as deviations from steady states using a HP filter.

can be located, some weight might be given to a rule of this form for monetary policy analysis.

5.4. The Augmented Rule and the Economy

The impulse responses when this augmented rule ($\phi_m = 1$) is used are shown in Figures 2 and 3. The results for both the augmented (solid) and benchmark (dotted) rule are plotted. We confine ourselves to depicting the effects of a shock to collateral and to monitoring.[28]

Figure 2 shows that with a positive collateral shock and the benchmark rule there is an increase in consumption and in goods sector employment and a fall in monitoring employment. With the augmented rule the effect on inflation is largely ameliorated. The effect on asset prices is reversed, as there is a smaller increase in goods employment and capital does not become as scarce. The effect on the EFP is the same in both cases, but the augmented rule helps to short-circuit the effects of the supply shock on inflation, asset prices, and bank lending.

For the shock to monitoring, shown in Figure 3, the effect is to better stabilize the economy, with smaller consumption, real wage, and inflation deviations. Again, the smaller increase in good sector employment means that capital does not become

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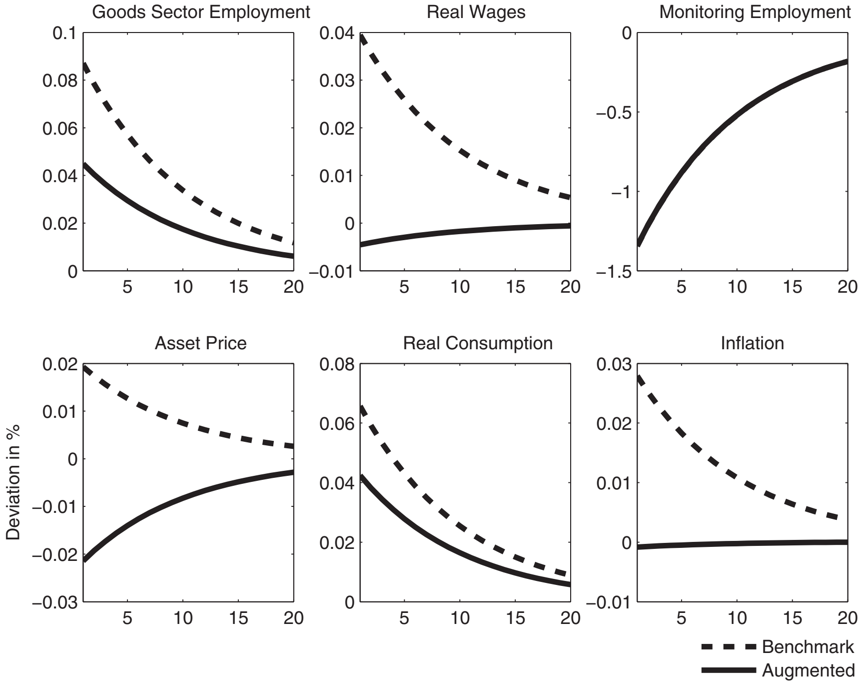

FIGURE 2. Key responses to positive collateral shock under benchmark and augmented rule.

quite so scarce in the case of the augmented rule, and there is a very small fall rather than an increase in the asset price.

6. CONCLUSIONS

Disruptions to financial markets since August 2007 have led to the widening of spreads and a significant contraction in the availability of money and credit to the private sector. To some extent, this is the mirror of the situation in previous years, when financial spreads narrowed as money and credit became more ample. The role of money both to originate and to reflect or amplify shocks seem especially important when there are shocks to the supply of loans. When setting monetary policy, central bankers monitor monetary developments (to varying degrees), but there seems to be little clear guidance as to how this information is to be used, if at all.

In this paper we have analyzed how a standard inflation-targeting rule is altered in the presence of a credit channel, and we find that when credit is supplied procyclically, simple inflation targeting may not be sufficient to stabilize the economy. We then examined the role of money in a DSGE model with an integrated banking sector that supplies loans and accepts deposits, along the lines of GM (2007),[29]

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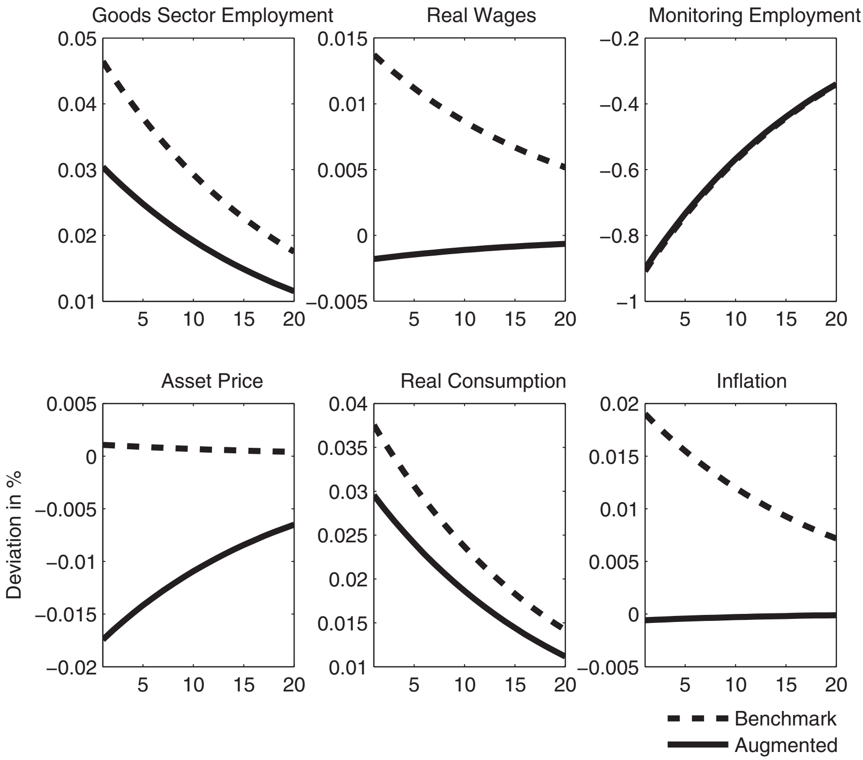

FIGURE 3. Key responses to positive monitoring shock under benchmark and augmented rule.

and established the pivotal role of money and the external finance premium. Although in normal circumstances money may convey little extra information to a central bank about the state of the economy over and above that in inflation, this is not true when there are dominant shocks to the supply of credit arising from changes in the value of collateral or the costs of monitoring a loan portfolio.[30] In these circumstances, if the central bank responds in some measure to opposing movements in money and the external finance premium, a much greater degree of control of inflation can be achieved, and so money can clearly matter.[31]

We have not necessarily captured all of the features of the present crisis or the boom that preceded it, because the external finance premium in this paper is confined to the relationship between banks and the private sector. Nevertheless, it is clear that an important role has also been played in recent monetary policy developments by the supply of money or credit at a finance premium internal to the financial system.[32] A model that captures other financial premia and other constituents of broad money or more generally liquidity would still lead to results similar to those in this paper; that is, the central bank ought to respond to shocks to the supply of money and credit when setting monetary policy.

NOTES

1. A modified version of the standard New Keynesian model with nonseparability in preferences [Aurouba and Schorfheide (2011)] also allows a nonnegligible role for money in the determination of output and inflation and thus, in the conduct of monetary policy. However, quantitative analysis documents the irrelevance of this channel.

2. Recently, Chadha et al. (2010) have found a significant role for supply shocks in explaining broad money movements prior to and subsequent to the financial crisis.

3. See Bernanke et al. (1999) for a clear exposition.

4. See Christiano et al. (2007) for a discussion of these issues.

5. See Curdia and Woodford (2010) for an alternative take on the importance of the EFP.

6. This intertemporal equation also operates as the basic asset pricing equation in a NK model.

7. The term κ is related to two deep parameters in the underlying Calvo–Yun model [see Yun (1996)]: the probability of firms maintaining a fixed price in the next period, τ, and the subjective discount factor, β. In inflation space, κ can be shown to be equal to $\frac{(1-\tau)(1-\tau\beta)}{\tau}$, and thus in price space, with the deviation in the price level proportional to inflation [see equation (6], the Phillips curve becomes $p_t = E_t p_{t+1} + (1-\tau\beta)(y_t - \hat{y}_t) + \frac{\tau}{1-\tau}\epsilon_{A,t}$. Under either formulation, inflation or the price level is less responsive to the output gap as $\tau \to 1$.

8. Which is an analogous 3×1 vector for the shocks.

9. See Woodford (2003) for a comprehensive treatment of this problem.

10. See also Gilchrist's comment (2008) on Goodfriend and McCallum's model (2007).

11. The model is fully derived in the extended Technical Appendix available from the authors' website.

12. The parameter $k_1 = \frac{(1+\gamma)kK}{c}$ is a function of the ratio of consumption to output, c, of the parameter reflecting the inferiority of capital as collateral, k, of steady-state capital, K, and of the trend growth rate, γ.

13. The parameter $k_2 = \frac{kK}{c}$ is a function of k, of steady-state capital, K, and of the steady-state ratio of consumption, c.

14. The parameter $\delta_1 = \frac{\beta(1-\delta)}{1+\gamma}$ is a function of the discount factor, β, of the depreciation rate of capital, δ, and of the trend growth rate, γ. The parameter $\gamma_1 = \frac{\beta\eta \mathrm{mc}}{1+\gamma}(\frac{n}{K})^{1-\eta}$ is function of steady-state employment in the goods sector, n, of steady-state marginal costs, mc, of steady-state capital, K, and of the parameter reflecting the capital share in the production function of the goods sector, η. Details of the derivation are reported in the Technical Appendix.

15. The collateralized external finance premium is simply the uncollateralized external finance premium multiplied by $(1-\alpha)$, i.e., the share of monitoring costs in loan costs, and it is less than the uncollateralized external finance premium. As the shares α and $(1-\alpha)$ are constant, both the collateralized and uncollateralized versions of the EFP coincide when log-linearized.

16. Tables A.1 and A.2 of the Appendix report the values for the parameters and steady-state values of relevant variables.

17. The policy rules are described in more detail in Section 5.

18. The equations for the steady states are listed in the extended Technical Appendix, available on request. The solution for the steady states uses a nonlinear routine in Maple, and the file is also available on request.

19. The diagrams of the impulse responses to mark-up, money, and government shocks are available on request. Those discussed here are available in the Technical Appendix, which can be found on the authors' web pages.

20. The benchmark model has 20 endogenous variables, $\{c, n, m, w, q, P, \pi, \mathrm{mc}, H, b, \Omega, \mathrm{EFP}, R^T, R^B, R, R^L, R^D, \lambda, \xi, T\}$, 5 lagged variables, $\{P_{-1}, H_{-1}, c_{-1}, b_{-1}, R^B_{-1}\}$ and 7 exogenous shocks, $\{a1, a2, a3, \varepsilon, \epsilon, \upsilon, u\}$. We report only the results of the four shocks $a1, a2, a3, \upsilon$.

21. For R_t^T this happens as $R_t^T = \lambda_t + E_t\pi_{t+1} - E_t\lambda_{t+1}$, where the inflation rate π and changes in $\lambda$are almost zero.
22. The liquidity service yield is sensitive to inflation dynamics, and as these are relatively stable here, the yield varies little. We explore this spread in other work. But note that in each case the direction of the liquidity service yield (not shown) is well explained by the direction of the external finance premium, and so we concentrate on understanding the responses of the EFP to shocks.
23. The additive nature of our household's utility function allows us to take a Taylor expansion of each term and substitute it back into the original function. The labor demand function is then rearranged for monitoring work, a second order expansion taken and substitution made. This process is then repeated for the marginal cost equation. Following Galí (2008) we substitute the resulting linear term in goods sector employment for a second order term in inflation using the sales equal net production constraint.
24. The welfare approximation is reported the Technical Appendix and draws on Chadha et al. (2012).
25. In terms of the Poole (1970) optimal choice of monetary policy instrument, it is clear that for sufficently large shocks to the supply side of the financial system, the standard assignment may be reversed.
26. We set the standard deviation of the banking shocks to 0.05 and fix the standard deviations of the real and monetary shocks to their benchmark values, as in Table 3. This gives a minimum of Φ_m equal to 0.54 when the the standard deviation of the two banking shocks is set to 0.01 and a maximum of Φ_m equal to 2.73 when the standard deviation of the two banking shocks is set to 0.05.
27. How the central bank should measure money and the EFP in reality, given the preponderance of possible measures, and then "learn" the appropriate weight on ϕ_m by constructing priors and updating posteriors, we leave to future work.
28. The results for shocks to productivity and velocity are available on request.
29. In some sense we follow the second conjecture of Christiano et al. (2007). We also produce a stronger result than Stracca (2013) about the importance of money.
30. Chadha et al. (2010) decompose money in demand and supply and assess the contribution of supply to money and EFP. They find that supply shocks have played a significant role in the time series in each of the United States, the United Kingdom, and the Eurozone in the short to medium term.
31. For a similar result from a search-theoretic perspective see Chiu and Meh (2011).
32. Banks before the crisis hardly felt the need to monitor or question the collateral of other banks. The current crisis has seen a freezing of the interbank market as banks began to closely monitor counterparty risk.
33. The full derivation of the first-order conditions and their log-linear formulation are described in Section A of the Technical Appendix, available from our webpages.
34. The model is defined in the Matlab file gmvsys.m. Standard deviation and persistence structure of the stochastic variables are defined in the driver file gmvdrv.m.
35. The relationship is derived by setting $b = \frac{B}{P(1+R^B)c}$.
36. Note that in the steady state $\frac{\xi}{\lambda} = \text{mc}$ and $\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{1+\gamma}$.
37. We define the percentage deviation from steady state of flow and stock variables by $\ln x_t - \ln x$, whereas for interest rates and ratio variables they are $R_t = R + \widehat{R}_t$ (rates) and $r_t = r + \widehat{r}_t$ (ratio, assuming $r_t = x_t/y_t$), respectively. It can be shown that the approximation comes from the first-order Taylor expansion $e^x \approx 1 + x$, whereas for the rate variable $\widehat{R}_t \approx \ln(1 + R_t) - \ln(1 + R)$ and for ratio $\widehat{r}_t = r_t - r = \ln(x_t/y_t) - \ln(x/y) = \widehat{x}_t - \widehat{y}_t$.
38. Log-linearization of interest rate is defined as difference from steady state: $R_t = R + \widehat{R}_t$.

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APPENDIX: THE LINEARIZED MODEL

The model[33] is composed of the following linearized equations.[34]

Supply of Labor:

$$\frac{n}{(1-n-m)}\widehat{n}_t + \frac{m}{(1-n-m)}\widehat{m}_t - \widehat{\lambda}_t - \widehat{w}_t = 0. \tag{A.1}$$

Demand for Labor:

$$\widehat{m}_t + \widehat{w}_t + \frac{(1-\alpha)c}{mw}\left(\widehat{c}_t + \frac{\phi}{\lambda}\widehat{\lambda}_t\right) = 0. \tag{A.2}$$

Supply of Banking Services:[35]

$$\begin{aligned}\widehat{c}_t &= \widehat{v}_t c + (1-\alpha)(a2_t + \widehat{m}_t)\\ &\quad + \alpha\left[\frac{bc}{bc+(1+\gamma)kK}(\widehat{c}_t + \widehat{b}_t) + \frac{kK(1+\gamma)}{bc+(1+\gamma)kK}(a3_t + \widehat{q}_t)\right],\end{aligned} \tag{A.3}$$

reported in the main text as

$$\widehat{c}_t = \left\{\begin{array}{c}\hat{v}_t c + (1-\alpha)(\hat{m}_t + a2_t)\\ + \alpha\left[\frac{b}{b+k_1}\hat{b}_t + \frac{k_1}{b+k_1}(\hat{q}_t + a3_t)\right]\end{array}\right\}\left(\frac{b+k_1}{b(1-\alpha)+k_1}\right), \tag{A.4}$$

where $k_1 = \frac{(1+\gamma)kK}{c}$.
CIA Constraint:

$$\widehat{c}_t + \widehat{P}_t = \widehat{H}_t + \widehat{v}_t. \tag{A.5}$$

Aggregate Supply:

$$\widehat{c}_t = (1-\eta)\left(1 + \frac{\delta K}{c}\right)(a1_t + \widehat{n}_t) - \frac{\delta K}{c}\hat{q}_t. \tag{A.6}$$

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Marginal Cost:

$$\widehat{\mathrm{mc}}_t = \widehat{n}_t + \widehat{w}_t - \widehat{c}_t. \quad \textbf{(A.7)}$$

Mark-Up:

$$\widehat{\mathrm{mc}}_t = \widehat{\xi}_t - \widehat{\lambda}_t. \quad \textbf{(A.8)}$$

Inflation:

$$\widehat{\pi}_t = \widehat{p}_t - \widehat{p}_{t-1}. \quad \textbf{(A.9)}$$

Calvo Pricing:

$$\widehat{\pi}_t = \kappa \widehat{\mathrm{mc}}_t + \beta E_t \widehat{\pi}_{t+1} + u_t. \quad \textbf{(A.10)}$$

Marginal Value of Collateralized Lending:

$$\widehat{\Omega}_t = \frac{kK}{bc + kK}\left(\widehat{c}_t - \widehat{q}_t - a3_t\right) - \frac{bc}{bc + kK}\widehat{b}_t, \quad \textbf{(A.11)}$$

reported in the main text as

$$\widehat{\Omega}_t = \frac{k_2}{b + k_2}\left(\widehat{c}_t - \widehat{q}_t - a3_t\right) - \frac{b}{b + k_2}\widehat{b}_t,$$

where $k_2 = kK/c$.

Asset Pricing:[36]

$$\begin{aligned}
&\widehat{q}_t\left[1 - k\Omega\left(\frac{\phi}{c\lambda} - 1\right)\right] \\
&= \left[\frac{\beta(1-\delta)}{1+\gamma} + \frac{\beta\eta\mathrm{mc}}{1+\gamma}\left(\frac{n}{K}\right)^{1-\eta}\right]\left(E_t\widehat{\lambda}_{t+1} - \widehat{\lambda}_t\right) + \frac{\beta(1-\delta)}{1+\gamma}E_t\widehat{q}_{t+1} \\
&+ \frac{k\Omega\phi}{c\lambda}\left(-\widehat{c}_t - \widehat{\lambda}_t\right) + k\Omega\left(\frac{\phi}{c\lambda} - 1\right)\left(\widehat{\Omega}_t + a3_t\right) \\
&+ \left(\frac{\beta\eta\mathrm{mc}}{1+\gamma}\left(\frac{n}{K}\right)^{1-\eta}\right)E_t\left[\widehat{\mathrm{mc}}_{t+1} + (1-\eta)\left(\widehat{n}_{t+1} + a1_{t+1}\right)\right], \quad \textbf{(A.12)}
\end{aligned}$$

reported in the main text as

$$\begin{aligned}
\widehat{q}_t &= (\delta_1 + \gamma_1)\left(E_t\widehat{\lambda}_{t+1} - \widehat{\lambda}_t\right) + \delta_1 E_t\widehat{q}_{t+1} - \frac{k\Omega\phi}{c\lambda}\left(\widehat{c}_t + \widehat{\lambda}_t\right) \\
&+ k\Omega\left(\frac{\phi}{c\lambda} - 1\right)\left(\widehat{\Omega}_t + a3_t\right) + \gamma_1 E_t\left[\widehat{\mathrm{mc}}_{t+1} + (1-\eta)\left(\widehat{n}_{t+1} + a1_{t+1}\right)\right],
\end{aligned}$$

where $\delta_1 = \frac{\beta(1-\delta)}{1+\gamma}$ and $\gamma_1 = \frac{\beta\eta\mathrm{mc}}{1+\gamma}(\frac{n}{K})^{1-\eta}$.

Government Budget Constraint:[37]

$$T\widehat{T}_t = H\left(\widehat{H}_t - \widehat{H}_{t-1}\right) + cb\widehat{b}_t - cb\left(1 + R^B\right)\left(\widehat{b}_{t-1} - \widehat{\pi}_t + \widehat{R}^B_{t-1}\right). \quad \textbf{(A.13)}$$

Bond Holding:

$$\widehat{b}_t = \varepsilon_t. \quad \textbf{(A.14)}$$

Riskless Interest Rate:

$$\widehat{R}^T_t = \widehat{\lambda}_t + E_t\widehat{\pi}_{t+1} - E_t\widehat{\lambda}_{t+1}. \quad \textbf{(A.15)}$$

Liquidity Service of Bonds:[38]

$$\frac{1 + R^B}{1 + R^T}\left(\widehat{R}^B_t - \widehat{R}^T_t\right) = \frac{\phi\Omega}{c\lambda}\left(\widehat{c}_t + \widehat{\lambda}_t\right) - \left(\frac{\phi}{c\lambda} - 1\right)\Omega\widehat{\Omega}_t. \quad \textbf{(A.16)}$$

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External Finance Premium:

$$\widehat{\mathrm{EFP}}_t = \widehat{v}_t + \widehat{w}_t + \widehat{m}_t - \widehat{c}_t. \tag{A.17}$$

Other Interest Rates:

$$\widehat{R}_t = \widehat{R}_t^T - \widehat{\mathrm{EFP}}_t, \tag{A.18}$$

$$\widehat{R}_t^L = \widehat{R}_t + \widehat{\mathrm{EFP}}_t, \tag{A.19}$$

$$\widehat{R}_t^D = \widehat{R}_t. \tag{A.20}$$

Policy Feedback Rule:

$$\widehat{R}_t = \phi_\pi \widehat{\pi}_t + \epsilon_t. \tag{A.21}$$

Velocity:

$$\widehat{v}_t = \upsilon_t. \tag{A.22}$$

For notational convenience the relevant log-linearized equations with variables denoting deviation from steady state are reported in the main text without $\widehat{\ }$. We consider contemporaneous shocks to $a1, a2, a3, v$. The benchmark model has 20 endogenous variables $\{c, n, m, w, q, P, \pi, \mathrm{mc}, H, b, \Omega, \mathrm{EFP}, R^T, R^B, R, R^L, R^D, \lambda, \xi, T\}$, 5 lagged variables $\{P_{-1}, H_{-1}, c_{-1}, b_{-1}, R^B_{-1}\}$, and 7 exogenous shocks $\{a1, a2, a3, \varepsilon, \epsilon, \upsilon, u\}$. The equations (A.1) through (A.22) and five lagged identities construct the model to be solved by the King and Watson (1998) algorithm. Tables A1–A3 provide a complete list of the endogenous and exogenous variables of the model and their meaning. Steady state of transfer level, Lagrangian of production constraint, and base money depend on the preceding parameters.

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TABLE A.1. The variables in Goodfriend and McCallum (2007)

c	Real consumption
n	Labor input
m	Labor input for loan monitoring, or "banking employment"
w	Real wage
q	Price of capital goods
P	Price level
P^A	Aggregate price level
π	Inflation
mc	Marginal cost
H	Base money
b	Real bond holding
Ω	Marginal value of collateral
EFP	External finance premium ($R^T - R$)
LP^B	Liquidity premium on bonds
LP^K	Liquidity premium on capital ($k\mathrm{LP}^B$)
R^T	Benchmark risk-free rate
R^B	Interest rate for bonds
R	Policy rate
R^L	Loan rate
R^D	Deposit rate
λ	Lagrangian for budget constraint (shadow value of consumption)
ξ	Lagrangian for production constraint
T	Real lump-sum transfer

TABLE A.2. Calibration

Parameter	Description	Value
β	Discount factor	0.99
κ	Slope of Phillips curve	0.05
α	Collateral share of loan production	0.65
ϕ	Consumption weight in utility	0.4
η	Capital share of firm production	0.36
δ	Depreciation rate of capital	0.025
γ	Trend growth rate	0.005
rr	Reserve ratio	0.005
F	Scaling coefficient in the production of loans	9
k	Relative inferiority of capital as collateral	0.2
θ	Elasticity of substitution of differentiated goods	11
ϕ_π^T	Response to inflation with inflation targeting	50
ϕ_π	Response to inflation	1.5
ϕ_y	Response to output	0.5
ϕ_q	Response to asset price growth	0.5
ρ	Smoothing parameter in the feedback rule	0.8
Steady state		
R^T	Steady state of benchmark risk-free rate	0.015
n	Steady state of labor input	0.3195
m	Steady state of banking employment	0.0063
R	Steady state of policy rate	0.0021
R^L	Steady state of loan rate	0.0066
R^B	Steady state of bond rate	0.0052
$\widetilde{b}$	Steady state level of bond holding	0.56
c	Steady state of consumption	0.8409
w	Steady state of real wage	1.9494
λ	Steady state of shadow value of consumption	0.457
v	Steady state level of velocity	0.31
Ω	Steady state of marginal value of collateral	0.237
K	Steady state of capital	9.19

TABLE A.3. Calibration of exogenous shocks

	Description	Value	Source
		Persistence	
ρ_{a1}	Productivity shocks	0.95	King (2002)
ρ_{a2}	Banking productivity shocks	0.95	Goodfriend and McCallum (2007)
ρ_{a3}	Collateral shocks	0.9	Goodfriend and McCallum (2007)
ρ_{ϵ}	Monetary policy shocks	0.3	King (2002)
ρ_{u}	Mark-up shocks	0.74	Smets and Wouters (2007)
ρ_{ε}	Government debt shocks	0.9	Chadha and Nolan (2007)
ρ_{v}	Velocity shocks	0.33	King (2002)
		Volatility	
σ_{a1}	Productivity shocks	0.72%	King (2002)
σ_{a2}	Banking productivity shocks	1.00%	Goodfriend and McCallum (2007)
σ_{a3}	Collateral shocks	1.00%	Goodfriend and McCallum (2007)
σ_{ϵ}	Monetary policy shocks	0.82%	King (2002)
σ_{u}	Mark-up shocks	0.11%	Smets and Wouters (2007)
σ_{ε}	Government debt shocks	1.00%	Chadha and Nolan (2007)
σ_{v}	Velocity shocks	1.00%	King (2002)