

# Reconnecting ‘Money’ to Inflation: the Pivotal Role of the External Finance Premium\*

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## Abstract

Monetary policy has become disconnected from the study of monetary aggregates. We consider re-connecting money to inflation using a model where banks supply loans to cash-in-advance constrained consumers on the basis of the value of collateral provided and the monitoring skills of banks. We show that when shocks to monitoring and collateral dominate those to productivity and the velocity of money demand, money and the external finance premium (EFP) become closely linked. This is because increases in asset prices or monitoring skills allow banks to raise the supply of loans leading to an expansion in aggregate demand, via a compression of the external finance premium, which is inflationary. Thus money and the EFP are negatively correlated when these banking sector shocks dominate. 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.

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# 1 Introduction

On the surface the quantity of money plays little or no active role in modern macroeconomic models, with money pinned down by plans formulated by households and firms for demand and production, which then determine inflation outcomes directly. In this sense the money stock does not appear to provide any independent source of macroeconomic fluctuations. Typically, it is the short term policy rate that regulates aggregate demand and is used as the instrument of monetary policy, with money supplied elastically to meet any idiosyncratic money market shocks. In such models the policy interest rate is sufficient to determine the constellation of market interest rates, and money (or credit) exerts no independent effect on the economy, via these other interest rates, and so becomes less worthy of study (Goodhart, 2007). Accordingly, current monetary policy practice is somewhat ambivalent about the role of monetary aggregates.

Although there is widespread agreement that in the long run there is, more or less, a one-to-one relationship between money growth and inflation and no relationship between money growth and real quantities (see Lucas, 1996), there is little consensus on what role monetary aggregates should play in the conduct of monetary policy over the short run when money might give a varying degree of guidance to short run movements in output and inflation. In this respect the European Central Bank follows a two-pillar approach. The first of these gives a prominent role to money (Stark, 2008). The second pillar relies on a ‘broadly based assessment of the outlook for future price developments’. By contrast the Federal Reserve explicitly eschews any role for money in the conduct of monetary policy. The Bank of England also places a less prominent weight on money, not least because financial liberalisation and changing payment technologies have masked the inflationary signal from growth in observed money aggregates.<sup>1</sup>

At the same time the role of banks, other financial institutions and the financial system - that provide liquidity and the markets in which asset prices are set - is given particular prominence in discussions of the transmission mechanism of monetary policy.<sup>2</sup> 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.<sup>3</sup> 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 re-examining the role that money, and more generally credit or liquidity, can play independently of the policy rate. One avenue we explore in this paper, is motivated by the role of money as a supply of payment services to liquidity constrained consumers. The premium price of such loans reflects the marginal costs to banks of their supply and so it responds to increases in the efficiency of supply relative to the demand for liquidity. 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

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<sup>1</sup>See Meyer (2001), Woodford (2007a) and (2007b) and King (2002).

<sup>2</sup>See Bernanke *et al* (1999) for a clear exposition.

<sup>3</sup>See Christiano, Motto and Rostagno (2007) for a discussion of these issues.

of posted collateral.

In this paper we examine the conditions under which studying the information content from the growth in money might add valuable information to the monetary policy maker about the current and prospective state of the economy. The key insight is whether observed money aggregates reflect a dominance of supply or demand shocks in the money market and thus whether observed interest rate spreads reflect aggregate demand driven need for higher levels of money balances or whether the supply of funds exogenously creates more money (or credit) and drives down interest rate spreads.<sup>4</sup> We show how financial conditions, as represented by the external finance premium, may feed back into aggregate demand and require the attention of monetary policy makers over and above that suggested by a simple interest rate rule that focuses on inflation alone.<sup>5</sup>

The paper is structured as follows. In section 2 we consider the role of money in a stylised macro model and show that it plays no exogenous role in determining the equilibrium for output and inflation. We then go on to consider a version of this model that, following Bernanke and Blinder (1988), allows for an external finance premium so that there is not always a one to one correspondence between the interest rate set by policymakers and that which lenders pay. 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 vigour with which policy responds to inflation. To help to flesh out this insight with a more fully specified and micro-founded model, in Section 3, we re-examine the role of money for policy in the context of Goodfriend and McCallum's (2007) model which incorporates a banking sector into a DSGE model and reconnects the money market perturbations and financial spreads back to equilibrium output and inflation. In Section 4, from an impulse response analysis generated from a calibration of the model dynamics around steady-state paths, 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 goods sector productivity. 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. One rule that has attractive properties we observe is when supply shocks dominate in the money market, spreads and money will move in opposite directions and so a rule that employs information about the difference in money and spreads, may be more stabilising for output and inflation. We show that this rule is better able to stabilise the economy compared to a simple inflation targeting rule when there are shocks to financial markets. Section 6 concludes and offers some directions for future work.

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<sup>4</sup>For an empirical analysis on how to identify supply and demand shocks in the banking sector, see Chadha, Corrado and Sun (2008).

<sup>5</sup>Even inflation targeting policymakers do concern themselves with output fluctuations and this is even more explicit under the Federal Reserve's dual mandate. As the two-sector economy we study involves the supply of banking services as an intermediate good, we concentrate on the implications of strict inflation targeting as a proxy for a central bank that does not pay attention to monetary aggregates as an intermediate target.

## 2 Money, Credit and Interest Rate Rules

In this section we take a stylised version of the New Keynesian model and show that as long as the policy rule satisfies the Taylor principle, output and inflation can be stabilised without regard to the money market. We re-examine this in a NK version of the Bernanke and Blinder (1988) credit model. Then we find that monetary policy also needs to be responsive to conditions in credit markets captured by the external finance premium (Meier and Müller, 2005).

First, we consider a simple model of money demand (for which supply is implicitly perfectly elastic) appended to a standard New Keynesian framework (see McCallum (2001) and King (2002)), which uses a monopolistically competitive supply side with Calvo price setting. In this section we examine in this simple setting what role the stock of money plays in determining equilibrium and show that it is essentially decoupled and plays no role in the determination of output and inflation.

We set up a simple New Keynesian model where 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  $\sigma$  is the intertemporal rate of substitution in output. This intertemporal equation also operates as the basic asset pricing equation in a New-Keynesian model. Equation (2) is the forward-looking New Keynesian Phillips curve that relates current inflation,  $\pi_t$ , to discounted expected next period inflation, where  $\beta$  is the subjective discount factor, and is proportional to the deviation of aggregate demand from supply, where  $\kappa$  is the slope of the Phillips curve.<sup>6</sup> 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 a semi-elasticity,  $\theta$ . Equation (4) is a simple interest rate-based rule that is used to stabilise inflation about its steady state value with the weight on inflation given by  $\phi_\pi$ . The supply side of the economy,  $\tilde{y}_t$ , which we interpret as the flex-price level of output is given by (5). Finally,  $\tau$  is the fraction of firms that hold prices fixed and so  $(1 - \tau)$  is the fraction which are given a signal to re-price as a mark-up over marginal costs (see Yun, 1996) thus inflation in equation (6) is simply the ratio of firms that re-price at the new price level,  $p_t$ , relative to those that cannot re-price.

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 to aggregate supply.

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

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

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

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<sup>6</sup>The term  $\kappa$  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,  $\tau$ , and the subjective discount factor,  $\beta$ . In inflation space  $\kappa$  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  $\tau \rightarrow 1$ .

$$R_t = \phi_\pi \pi_t + \epsilon_{D,t} \quad (4)$$

$$\tilde{y}_t = \epsilon_{E,t} \quad (5)$$

$$\pi_t = \frac{1 - \tau}{\tau} p_t. \quad (6)$$

We can substitute (4) into (1), (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:

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

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  $3 \times 3$  matrix. The existence or not of a unique solution for  $\mathbf{x}_t$ , as is well understood, given the forcing processes,  $\epsilon_t$ ,<sup>7</sup> will depend upon matching the number of eigenvalues of the matrix  $\mathbf{\Lambda}$  within the unit circle with the number of predetermined state variables (see, for example, Blanchard and Kahn, 1980). And typically the coefficients of the policy rule, (4), are set to ensure local determinacy.<sup>8</sup>

What concerns us here is the role, if any, that money,  $h_t$ , plays in this economy. We note that the matrix,  $\mathbf{\Lambda}$ , can be written in block form:

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

Where  $A$  is  $2 \times 2$ ,  $C$  is  $1 \times 2$ ,  $D$  is a  $1 \times 1$  null matrix and  $0$  is a  $2 \times 1$  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  $\mathbf{D}$  is a null matrix. In this case, with both inflation and output non-predetermined, determinacy will require  $A$  to have two eigenvalues outside the unit circle and for the trace  $Tr(A)$  to be positive. This requires the  $Det(A) - Tr(A) > -1$ , for which a necessary and sufficient condition is that:

$$\phi_\pi > 1. \quad (8)$$

Which is the familiar condition that for stability real rates must increase (decrease) by more than any positive (negative) inflation shock. We illustrate this result in Figure 1. The  $45^\circ$  line corresponds to the Fisher equation. Where this line intercepts the vertical line at zero inflation we have the real interest rate. It is assumed that there is a positive inflation target corresponding to equation (8) so the policy function is steeper than the Fisher equation.

<sup>7</sup>Which is an analogous  $3 \times 1$  vector for the shocks.

<sup>8</sup>See Woodford (2003) for a comprehensive treatment of this problem.

The solution is recursive in that as long as inflation and output are pinned down to a unique solution path then the money stock (and the price level) is (are) also determined in each period. In other words there is simply no role in this economy for the money stock to destabilise the economy independently. To break this result we need a separate supply function for money which will create some disequilibrium in the money market and thus some impetus to nominal expenditures or some cause for disconnect across interest rates, so that the interest rate entering the policy rule is not necessarily the same as the return from bonds or other risky investments.<sup>9</sup>

## 2.1 Credit in a NK Model

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 equation (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:

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

The Phillips curve is (2) as above. 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  $\gamma_c$  can be interpreted as a measure of the extent of leverage of loans over deposits, while the costs of monitoring or the availability of collateral would be reflected in  $\alpha_c$ .

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

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

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

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

$$(d_t - p_t) = y_t. \quad (3')$$

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 loan supply:

$$R_t^m = R_t - \frac{\gamma_c}{\alpha_c + \beta_c} y_t = R_t - \lambda_c y_t \quad (11)$$

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

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

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<sup>9</sup>We outline the various financial spreads resulting from this model in Section 3.

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

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

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

In contrast to the earlier model the policymaker 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 loans supply relative to their deposit base i.e. their leverage. In so far that the parameters in the loan supply function (9)  $\alpha_c$  and  $\gamma_c$  are procyclical we can see a role for the monetary authority to respond more vigorously to developments in financial markets coming from the supply of credit. We can illustrate this point in Figure 1. With possible shocks to the supply of loans the slope of policy reaction function will alter.

Hence the altered condition (14) tells us that if money/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 policymaker has to offset that spread as well as ensuring 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 the 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 reconnected to general equilibrium models as they affect consumption decisions of liquidity constrained households and the spreads across several financial instruments and assets. And as Woodford (2007a) 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 simple way to incorporate money and financial spreads into a general equilibrium setting is to study the banking sector proposed by Goodfriend and McCallum (2007).<sup>10</sup> 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 (EFP). Figure 2 describes the timeline of events in the model.

The main feature of this model is the underpinning of household, production and the monetary authority with a banking sector. Households, who are liquidity constrained, decide the amount

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<sup>10</sup>See also Gilchrist’s comment (2008) on Goodfriend and McCallum’s model (2007).

of consumption and the amount of labour 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), characterised by monopolistic competition and Calvo pricing, with a standard Cobb-Douglas production function, subject to productivity shocks. Profit maximising firms decide the amount of production they wish to supply and the demand for labour. By clearing the household and production sectors we can define the equilibrium in the labour 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 amount 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 following sub-sections describe in more details the building blocks of the model and also report the main log-linearised relationships that will be used later in the simulations. The Appendix lists all the equations while Table 1 describes the variables in the model.

### 3.1 Households and the Production Sector

Households are liquidity constrained and decide the amount of consumption and the amount of labour they wish to supply to the production sector and to the banking sector according to the following utility function:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t [\phi \log(c_t) + (1 - \phi) \log(1 - n_t^s - m_t^s)], \quad (15)$$

where  $c_t$  denotes real consumption,  $n_t^s$  is the supply of labour in the goods sector and  $m_t^s$  is the supply of monitoring work in the banking sector. They are subject to the budget constraint:

$$\begin{aligned} q_t(1 - \delta)K_t + \frac{\gamma B_t}{P_t^A} + \frac{D_{t-1}}{P_t^A} + w_t(n_t^s + m_t^s) + c_t^A \left(\frac{P_t}{P_t^A}\right)^{1-\theta} \\ - w_t(n_t + m_t) - \frac{D_t}{P_t^A} - tax_t - q_t K_{t+1} - \frac{\gamma B_{t+1}}{P_t^A(1 + R_t^B)} - c_t, \end{aligned} \quad (16)$$

where  $q_t$  is the price of capital,  $K_t$  is the quantity of capital which depreciates at a rate  $\delta$ ,  $P_t$  is the price of the good produced by households,  $P_t^A$  is the consumption price index,  $n_t$  is labour demanded by the household as producer,  $m_t$ , is the labour demanded by household's banking operation,  $w_t$  is the real wage,  $D_t$  is the nominal holding of broad money,  $tax_t$  is the real lump-sum tax payment,  $R_t^B$  is the nominal interest rate on government bonds purchased in  $t + 1$ ,  $B_{t+1}$ . The Lagrange multiplier of this constraint is denoted as  $\lambda_t$  and  $\theta$  is the elasticity of households'

demand. Households choose the level of monitoring work,  $m_t$ , and the level of employment work,  $n_t$ , they wish to offer to the production and the banking sectors.

At the same time households' consumption, given the cash-in-advance constraint, depends on the amount of loanable funds they can obtain:

$$c_t = v_t D_t / P_t^A \quad (17)$$

where  $v_t$  denotes velocity and  $D_t$  are deposits.<sup>11</sup>

The production sector, characterised by monopolistic competition and Calvo pricing, uses a standard Cobb-Douglas production function with capital,  $K_t$ , and labour,  $n_t$ , subject to productivity shocks. Firms decide the amount of production they wish to supply and the demand for labour by equalising sales to net production:

$$K_t^\eta (A1_t n_t)^{1-\eta} - c_t^A (P_t / P_t^A)^{-\theta} = 0, \quad (18)$$

where  $A1_t$  is a productivity shock in the goods production sector whose mean increases over time at a rate  $\gamma$ . The Lagrange multiplier of this constraint is denoted as,  $\xi_t$ . These two sectors also provide the standard relationship for the riskless interest rate and the bond rate. By clearing the household and production sectors,<sup>12</sup> we can define the equilibrium in the labour market and in the goods market. Specifically the total supply of labour is given by:

$$n_t^s + m_t^s = 1 - \frac{(1 - \phi)}{w_t \lambda_t} \quad (19)$$

which depends positively on wages  $w_t$ , which is the same for the two types of labour, and on the shadow value of consumption,  $\lambda_t$ . Finally the demand for monitoring work:

$$m_t = \left( \frac{\phi}{\lambda_t c_t} - 1 \right) \frac{1 - \alpha}{w_t} c_t \quad (20)$$

depends negatively on wages,  $w_t$ , and positively on consumption,  $c_t$ .

## 3.2 Banking Sector

We now turn to the analysis of how the banking sector affects the economy. The production function pertaining to management of loans,  $L_t$ , is given by:

$$L_t / P_t^A = F(\gamma b_{t+1} + A3_t k q_t K_{t+1})^\alpha (A2_t m_t)^{1-\alpha} \quad 0 < \alpha < 1, \quad (21)$$

where  $A2_t$  denotes a shock to monitoring work,  $A3_t$  is a shock to capital as collateral and  $b_t = B_{t+1} / P_t^A (1 + R_t^B)$ . The parameter  $k$  denotes the inferiority of capital as collateral in the banking production function, while  $\alpha$  is the share of collateral in the loan production function.

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<sup>11</sup>Clearly velocity shocks are an important objection to the quantity theory at the business cycle frequency (Teles and Uhlig, 2009) and hence to the possibility of using money as information for an inflation targeting central bank. Whether endogenously or exogenously varying, we can understand better the information content by adopting time variation in velocity and stacking that up against the other shocks.

<sup>12</sup>For details on the model set-up, derivation and notation see the technical appendix, available on request.

Increasing monitoring effort is achieved by increasing the number of people employed in the banking sector which reduces employment in the production of goods.

While in standard Calvo-Yun models nominal consumption plans pin down the demand for money, in this model with banking, money is produced by banks, so any shift in the supply of loanable funds generated by shocks to monitoring effort or collateral also affects consumption. Specifically the banking sector matches deposit demand from liquidity constrained consumers with a technology to produce loans by substituting monitoring work for collateral in supplying loans, where total loans required result from the reserve/deposit ratio,  $rr$ :<sup>13</sup>

$$L_t = (1 - rr)D_t. \quad (22)$$

Simple substitution of the bank's loan production function into the household's cash in advance constraint (17) leads to:

$$c_t = v_t \frac{F(\gamma b_{t+1} + A3_t k q_t K_{t+1})^\alpha (A2_t m_t)^{1-\alpha}}{P_t^A (1 - rr)}. \quad (23)$$

The differentiation of (23) with respect to  $K_{t+1}$  gives an expression  $\Omega_t A3_t k q_t$  which is a function of the marginal value of collateralised lending:

$$\Omega_t = \frac{c_t \alpha}{\gamma b_{t+1} + A3_t k q_t K_{t+1}} \quad (24)$$

which depends on consumption,  $c_t$ , and on the value of the collateral,  $q_t$  and  $b_t$ . This expression also enters in the asset price equation:

$$q_t = \frac{\left( E_t \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} (1 - \delta) \beta + E_t \beta \eta \left[ \frac{\lambda_{t+1}}{\lambda_t} \frac{\xi_{t+1}}{\lambda_{t+1}} \left( \frac{A1_t n_t}{K_t} \right)^{1-\eta} \right] \right)}{\left( 1 - \left( \frac{\phi}{c_t \lambda_t} - 1 \right) \Omega A3_t k \right)}. \quad (25)$$

Finally the Central Bank sets the policy rate which affects the constellation of interest rates spreads, which we explore further in section 3.4.

### 3.3 Consumption, monitoring work and asset prices

We now describe in more detail the main log-linear relationships of the model.<sup>14</sup> In our notation variables without time subscripts denote steady-state values whereas those with a time subscript denote log-deviation from steady-state. A log-linear formulation of (23) shows how loanable funds affect the consumption of liquidity constrained consumers:

$$c_t = \left\{ \begin{array}{l} v_t c + (1 - \alpha)(m_t + a2_t) + \\ \alpha \left[ \frac{b}{b+k_1} b_t + \frac{k_1}{b+k_1} (q_t + a3_t) \right] \end{array} \right\} \left( \frac{b + k_1}{b(1 - \alpha) + k_1} \right). \quad (26)$$

<sup>13</sup>Given the bank balance sheet  $H_t + L_t = D_t$  and  $D_t = L_t / (1 - rr)$  it follows that  $H_t = rr D_t$ . So in a log-linearised version of the model high-powered money,  $H_t$ , is equal to the level of deposits,  $D_t$ , and therefore loans,  $L_t$ .

<sup>14</sup>The technical appendix describes in detail the full set of equations used in the simulation.

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  $\alpha$  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 as liquidity.<sup>15</sup>

The demand for monitoring work, which derives from (20), is given by:

$$m_t = -w_t - \frac{(1 - \alpha)c}{mw} \left( c_t + \frac{\phi}{\lambda} \lambda_t \right). \quad (27)$$

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,  $\lambda_t$ . The steady state parameters,  $m$ ,  $w$ , and  $\frac{\phi}{\lambda}$  represent the steady-state proportions 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.

The total supply of labour, from (19), is given by:

$$nn_t + mm_t = (1 - n - m) (\lambda_t + w_t) \quad (28)$$

which depends positively on wages,  $w_t$ , and on the shadow-value of consumption,  $\lambda_t$ .

With a banking sector of this type in the model, we can link money and asset prices directly to output and inflation, as 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, the level of economic activity and will also have implications for asset prices.

A key term here is the marginal value of collateralized lending,  $\Omega_t$ , from (24), which increases as consumption rises and falls as collateral becomes more widely available:

$$\Omega_t = \frac{k_2}{b + k_2} (c_t - q_t - a3_t) - \frac{b}{b + k_2} b_t. \quad (29)$$

$\Omega_t$  depends on the value of the collateral,  $q_t$  and  $b_t$ , on a collateral shock,  $a3_t$ , and on consumption,  $c_t$ . Higher levels of consumption increase the marginal value of capital and hence the collateral value,  $q_t$ . The increase in collateral value leads to more borrowing and more consumption. The parameter  $k_2$  is again a composite coefficient similar to  $k_1$ .<sup>16</sup>

<sup>15</sup>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,  $\gamma$ .

<sup>16</sup>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,  $c$ .

The marginal value of collateralized lending also feeds back into the capital asset price equation,  $q_t$ , which is defined in (25):

$$q_t = (\delta_1 + \gamma_1)(E_t \lambda_{t+1} - \lambda_t) + \delta_1 E_t q_{t+1} - \frac{k\Omega\phi}{c\lambda}(c_t + \lambda_t) + k\Omega\left(\frac{\phi}{c\lambda} - 1\right)(\Omega_t + a3_t) + \gamma_1 E_t [mc_{t+1} + (1 - \eta)(n_{t+1} + a1_{t+1})]. \quad (30)$$

In (30) the marginal value of collateralized lending,  $\Omega_t$ , potentially can amplify asset price volatility and magnify the response of the economy to both real and financial shocks. Both real,  $a1$ , and financial shocks,  $a3$ , directly feed back into asset prices alongside the expected marginal productivity of capital  $[mc_{t+1} + (1 - \eta)(n_{t+1} + a1_{t+1})]$  where  $mc_{t+1}$  denotes marginal cost in period  $t+1$ ,  $\eta$  is the share of capital in the goods production function and  $n$  is employment in the goods production sector. Similarly expected asset prices,  $E_t q_{t+1}$ , 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  $\delta_1$  is a composite function of the depreciation rate of capital while the parameter  $\gamma_1$  is a composite function of steady-state marginal costs, of steady-state employment in the goods sector and of the capital share in the production of goods.<sup>17</sup>

### 3.4 Market Interest Rates

The last building block in the Goodfriend and McCallum's (2007) model is 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. Basically it boils down to a one-period Fisher equation:

$$R_t^T = E_t(\lambda_t - \lambda_{t+1}) + E_t \pi_{t+1}. \quad (31)$$

The policy rate is set by a feedback rule responding to inflation,  $\pi_t$ , with parameters,  $\phi_\pi^T$ , where we assume that the policymaker targets zero percent inflation, as in GM:

$$R_t = \phi_\pi^T \pi_t + \epsilon_t. \quad (32)$$

The difference between  $R_t^T$  and the policy rate  $R_t$  is equal to the external finance premium,  $EFP_t$ . To find the  $EFP$  we must equate the marginal product of real loans per unit of labour,  $(1 - \alpha)\frac{L_t/P_t}{m_t}$ , to their real marginal cost,  $w_t$ .<sup>18</sup> Thus, the policy rate  $R_t$  is less than  $R_t^T$  by the extent of the external finance premium,  $EFP_t = \frac{v_t m_t w_t}{c_t(1-\alpha)(1-rr)}$ , which is the premium paid by the private sector for loans:

<sup>17</sup>The parameter  $\delta_1 = \frac{\beta(1-\delta)}{1+\gamma}$  is a function of the discount factor,  $\beta$ , of the depreciation rate of capital,  $\delta$ , and of the trend growth rate,  $\gamma$ . The parameter  $\gamma_1 = \frac{\beta\eta mc}{1+\gamma}\left(\frac{n}{K}\right)^{1-\eta}$  is function of steady-state employment in 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,  $\eta$ . Details of the derivation are reported in the technical appendix, see equation (A.12).

<sup>18</sup>Note that with a fractional reserve system the following relationship holds  $L_t = D_t(1 - rr) = \frac{c_t P_t^A}{v_t}(1 - rr)$  where  $L$  is the amount of loans,  $D$  are deposits and  $rr$  is the fractional reserves/deposit ratio.

$$R_t = R_t^T - \underbrace{[v_t + w_t + m_t - c_t]}_{EFP_t}. \quad (33)$$

The external finance premium,  $EFP_t$ , is the real marginal cost of loan management, and it is increasing in velocity,  $v_t$ , real wages,  $w_t$ , monitoring work in the banking sector,  $m_t$ , the share of collateral cost in loan costs ( $\alpha$ ), reserve requirements ( $rr$ ),<sup>19</sup> and is decreasing in consumption,  $c_t$ .<sup>20</sup>

The yield on government bonds is derived by maximising households' utility with respect to bond holdings,  $R_t^T - R_t^B = \left[ \frac{\phi}{c_t \lambda_t} - 1 \right] \Omega_t$ . In its log-linear form it is the riskless rate,  $R_t^T$ , minus the liquidity service on bonds, which can be interpreted as a liquidity premium<sup>21</sup>:

$$R_t^B = R_t^T - \underbrace{\left[ \frac{\phi \Omega}{c \lambda} (c_t + \lambda_t) - \left( \frac{\phi}{c \lambda} - 1 \right) \Omega \Omega_t \right]}_{LP_t^B}, \quad (34)$$

where  $(c_t + \lambda_t)$  measures the household marginal utility relative to households shadow value of funds while  $\Omega_t$  is the marginal value of the collateral. It is in fact these key margins - the real marginal cost of loan management versus the liquidity service yield - that determine the behaviour of spreads. In the above expression,  $\phi$  denotes the consumption weight in the utility function whereas  $\lambda_t$  is the shadow value of consumption,  $c_t$ .

The interest rate on deposits depends on the policy rate,  $R_t$ :

$$R_t^D = R_t(1 - rr). \quad (35)$$

In this section we have outlined the McCallum and Goodfriend model and explained how it links output explicitly to developments in the monetary sector and how the interaction between these sectors determine financial spreads. In the following section we analyse the key responses of the model to a series of shocks and try to infer what is the possible relationship between money and inflation.

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<sup>19</sup>As these two parameters are both constant in this paper they do not appear in the log-linearisation. We relax this assumption in other work.

<sup>20</sup>The collateralised external finance premium is simply the uncollateralised external finance premium multiplied by  $(1 - \alpha)$ , i.e. the share of monitoring costs in loan costs, and it is less than the uncollateralised external finance premium. As the shares  $\alpha$  and  $(1 - \alpha)$  are constant both the collateralised and uncollateralised versions of the EFP coincide when loglinearised.

<sup>21</sup>The EFP and the liquidity services on bonds and capital, which we call liquidity premium (LP) are directly related to each other. Specifically  $LP_t^K = k \times LP_t^B = k \Omega_t [(1 - rr)/v_t] EFP_t$ . So given the substitution between monitoring and collateral an increase in the real marginal cost of loans production due to any additional monitoring effort, puts up the liquidity service from collateral which can be interpreted as a 'rent' paid to borrowers for the collateral services that their assets provide in the banking loan production function.

## 4 Model Results

The model<sup>22</sup> is solved using the solution methods of King and Watson (1998)<sup>23</sup> who also provide routines to derive the impulse responses of the endogenous variables to different shocks, to obtain asymptotic variance and covariances of the variables and to simulate the data.<sup>24</sup> The simulation is carried out by running random number generation in Matlab. Following a fixed random seed, we generate a set of normal distributed exogenous shocks of the length  $K = 10,000$ . These random shocks are fed into the recursive law of motion of key variables described by the model solution for which see the Technical annex.

For the impulse response analysis and simulation exercise we examine the effects of the real and financial shocks described in Table 3. We also report the choice of moments for the forcing variables. These are standard parameters in the literature. The various impulses and asymptotic moments are shown in Figures 3-11.

### 4.1 Calibration

Table 2 reports the values for the parameters and steady-state values of relevant variables. Following Goodfriend and McCallum (2007) we choose the consumption weight in utility,  $\phi$ , to give 1/3 of available time in either goods or banking services production. We also set the relative share of capital and labour in goods production  $\eta$  to be 0.36. We choose the elasticity of substitution of differentiated goods,  $\theta$ , to be equal to 11. The discount factor,  $\beta$ , is set to 0.99 which is the canonical quarterly value while the mark-up coefficient in the Phillips curve,  $\kappa$ , is set to 0.05. The depreciation rate,  $\delta$ , is set to be equal to 0.025 while the trend growth rate,  $\gamma$ , is set to 0.005 which corresponds to 2% per year. The steady-state value of the ratio of bond holdings to GDP,  $\tilde{b}$ , 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 US 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 US bank reserves to M3 as at the fourth quarter 2005. The fraction of collateral,  $\alpha$ , in loan production is set to 0.65, the coefficient reflecting the inferiority of capital as collateral,  $k$ , is set to 0.2 while the production coefficient of loan,  $F$ , 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, we set the coefficient on inflation with inflation targeting,  $\phi_\pi^T$ , to be equal to 50 as in GM in order to reflect a strong response to inflation and a smoothing parameter,  $\rho$ , equal to 0.8; the coefficient on inflation with

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<sup>22</sup>The log-linearized equations for the model are listed in Appendix A. The full derivation of the model is also described in section A of the Technical Appendix, available on request.

<sup>23</sup>King and Watson's MATLAB code is generalized in the sense that we use three MATLAB files. The three files for the solution of our benchmark model `gmvsys.m`, `gmvdrv.m` and `gmvcon.m` are available on request.

<sup>24</sup>King and Watson's package includes standardized auxiliary programs `impkw.m` to generate the impulse responses to different shocks to the endogenous variables and the program `fdfkw.m` to obtain the filtered autocovariances and the filtered second moments from the model solution. The program `impkwsimu.m` simulates the artificial series and allows to generate HP filtered data.

a Taylor rule,  $\phi_\pi$ , is set to 1.5 while the coefficient on output,  $\phi_y$ , is set to 0.5 as in GM. For the rule which responds to asset prices we assume a coefficient on asset price growth,  $\phi_q$ , equal to 0.5. Finally, for the sensitivity analysis of the ratio of banking to real shocks,  $\Phi_m$ , we examine the ratio the standard deviation of quarterly real M2 growth to real output growth in rolling 5-year window to 2009 and find that there was a maximum of 4.7 on October 1989 and a minimum of 0.44 in April 1995 and so we calibrate  $\Phi_m$  on a range between 1 and 5.<sup>25</sup>

## 4.2 Implied Steady-States

With these parameters values we see that the steady state of labour input,  $n$ , is 0.31 which is close to 1/3 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 the 1.6%, share of total US 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 collateralised 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 US.<sup>26</sup>

## 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, velocity and to two types of shocks to the financial sector.<sup>27</sup> As is implied by Section 2, the dynamics of the model suggests that a key role is played by the external finance premium 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.

Figure 3 describes the effects of a shock,  $a1$ , to goods productivity.<sup>28</sup> Under the inflation targeting rule inflation is stabilised. Hence hours worked in the goods production sector,  $n$ , and the benchmark rate  $R^T$  are almost invariant to the shock.<sup>29</sup> However  $c$ ,  $w$ ,  $q$ ,  $m$  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

<sup>25</sup>The data are from the St Louis Reserve Bank FRED data series and we use, M2SL for the money stock, CPIAUCSL, for the CPI urban all-items, and GDPC96 for real GDP.

<sup>26</sup>The equations for the steady-states are listed in section B of the Appendix. The solution for the steady-states uses a nonlinear routine in Maple and the file is also available on request.

<sup>27</sup>Additional impulse responses to mark-up, money and government shocks are available on request.

<sup>28</sup>The benchmark model has 20 endogenous variables  $\{c, n, m, w, q, P, \pi, mc, H, b, \Omega, EFP, R^T, R^B, R, R^L, R^D, \lambda, \xi, T\}$ , 5 lagged variables  $\{P_{-1}, H_{-1}, c_{-1}, b_{-1}, R_{-1}^B\}$  and 7 exogenous shocks  $\{a1, a2, a3, \varepsilon, \epsilon, v, u\}$ . We report only the results of the four shocks  $a1, a2, a3, v$ .

<sup>29</sup>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  $\pi$  and changes in  $\lambda$  are almost zero.

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 as we have pointed out 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.

Figure 4 describes the effects of a shock to banking productivity,  $a2$ . Again under inflation targeting the rule is stabilising and therefore so is the benchmark interest rate  $R^T$ . Because of higher banking productivity, monitoring hours,  $m$ , decline while there is little effect on the value of collateral  $q$ , on consumption  $c$  and on real wages  $w$ . The combined effect is to decrease the EFP and so here money might indicate some loosening of financial conditions.

Figure 5 reports the effects of a positive shock to collateral,  $a3$ . Under inflation targeting inflation is stable and so is the benchmark interest rate  $R^T$ . There are implied small changes in  $c$  and  $w$ . As we have a positive shock on collateral there will be a fall in monitoring hours  $m$ . The joint effect is to reduce the EFP, alongside an increase in the quantity of money.

Figure 6 reports the effect of a positive shock to velocity  $v$  with an inflation targeting rule. There is an increase in  $c$ ,  $w$ ,  $n$  and inflation. Because the capital/labour ratio is lower, the price of capital  $q$  rises while hours of monitoring,  $m$ , decrease. The joint effect is a decrease in the EFP and a fall in the money supply. 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.<sup>30</sup> And 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 which drives the EFP in the opposite direction to that of the quantity of loans and so can act to compress (unwind) yields when there 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 given by Table 3 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 4 - for the benchmark shocks and banking dominant shocks - shows, on the left hand side of the table the lead, contemporaneous and lagged correlation 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 4 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.

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<sup>30</sup>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.

## 5 Reconsidering Policy Rules

The previous section has shown that financial conditions might matter when setting monetary policy. The model properties with respect to each shock are summarised in Table 5. We concentrate on comparing shocks to the supply of banks loans to those from productivity or velocity. Shocks to productivity and to velocity have symmetric effects on money and the external finance premium. A positive shock to productivity raises both the demand for money and the external finance premium. A negative shock to velocity has a similar effect. However, 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 differently signed effect 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 to say 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 (2006) compared with the inflation targeting rule given by equation (32). For the parameter values see Table 2. We use the following 3 alternative rules for comparison.

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

$$R_t = \rho R_{t-1} + (1 - \rho)(\phi_\pi \pi_t + \phi_y y_t) + \epsilon_t \quad (36)$$

with  $0 < \rho < 1$ . In contrast to the inflation targeting rule (32) where the policymaker targets zero inflation, the weight on inflation,  $\phi_\pi$ , is lower at 1.5.

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

$$\Delta h_t = \rho^H \Delta h_{t-1} + \epsilon_t \quad (37)$$

where  $h_t = \log(H_t)$  and  $\Delta h_t$  denotes the growth rate of  $H_t$ . In (37) we assume that  $0 < |\rho^H| < 1$  while  $\epsilon_t$  is the random component of policy behaviour.

**Policy Rule with Asset Price Growth.** We also consider, as in Gilchrist and Saito (2006), an alternative formulation of (36) where the policy-maker responds to the growth rate of observed asset prices,  $\Delta q_t$ :

$$R_t = \rho R_{t-1} + (1 - \rho)(\phi_\pi \pi_t + \phi_q \Delta q_t) + \epsilon_t \quad (38)$$

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

## 5.1 Welfare Analysis of Policy Rules

We evaluate each rule under a variety of different shocks by calculating the standard loss function:<sup>31</sup>

$$L = 0.5\sigma_{\pi}^r + 0.5\sigma_y^r,$$

where  $\sigma_{\pi}^r$  and  $\sigma_y^r$  denote the *relative* standard deviation of output or inflation to the benchmark calibration.<sup>32</sup> So if losses increase as the standard deviation of the shocks rise, they increase relative to the losses of the same rule under the benchmark calibration. The exercise here is to vary the ratio of the standard deviation of financial to real and velocity shocks,  $\Phi_m$ , defined as:

$$\Phi_m : \frac{\sigma_{mon} + \sigma_{col}}{\sigma_{prod} + \sigma_{vel}}.$$

Figure 7 traces out the effect on the policy losses of a steadily rising ratio of financial to productivity and velocity shocks (with  $\Phi_m$  on the x-axis) in the model outlined in Section 3. As the relative standard deviation of shocks to collateral and monitoring rises, in our simulations, the loss increases and clearly suggests that an inflation targeting or an asset-price rule fails to exploit the information from money and the external finance premium. By contrast a rule with money, by controlling directly the growth of monetary and financial aggregates, does as well as the benchmark rule as it offsets the variance in loans supply directly.

### 5.1.1 An augmented rule

As an illustration of how policymakers might seek to respond 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 in the form to capture the impact of supply of money:

$$R_t = \phi_{\pi}^T \pi_t + \phi_m (h_t - EFP_t) + \epsilon_t, \quad (39)$$

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 Figure 8 we vary the loading  $\phi_m$  on the spread, holding the relative standard deviation of the shocks fixed with  $\Phi_m = 5$ . We note that the loss,  $L$ , is initially declining in  $\phi_m$ . And so it seems clear that over some range when financial shocks are dominant inflation can be better stabilised. For this illustrative calculation

<sup>31</sup>Given the primitive utility function, we could trace out the direct welfare consequences for the representative household but as these are typically found to be proportional to the variance of inflation and output, we trace these paths for simplicity. See Woodford, 2003.

<sup>32</sup>In the benchmark calibration the standard deviation of banking shocks is set at 1% as in Table 3.

the standard deviation is minimised at around  $\phi_m = 1$ .<sup>33</sup> 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 stabilisation of inflation by exactly offsetting any narrowing or widening of the spread between the external finance premium and money.

We now turn to an evaluation of the augmented rule relative to the other rules we have already considered. To do this we again follow Gilchrist and Saito (2006) and calculate the gain from the use of a policy rule  $x$  as:

$$Gain(x) = \frac{L(Taylor) - L(Rule\ x)}{L(Taylor) - L(Augmented)}$$

as the difference between the loss,  $L$ , obtained from pursuing policy rule  $x$  versus the Taylor rule, divided by the difference between outcomes obtained from pursuing the augmented rule, which is the most stabilising rule, versus the Taylor rule. Doing so enables us to summarise 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. In Figure 8 we can see that as we increase the size of banking shocks the asset-price rule deteriorates relative to the augmented rule because it does not distinguish between demand or supply shock driven changes in asset price. By contrast the gain from a money rule rises, and while 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.<sup>34</sup>

## 5.2 Money under alternative rules

The correlations between inflation, money and EFP are tabulated for the two different policy rules in Table 6. 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, suggesting that the augmented rule does not help stabilise 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 are 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

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<sup>33</sup>How the central bank should measure money and the EFP in reality, given the preponderance of possible measures, and then ‘learn’ by about the appropriate weight on  $\phi_m$  constructing priors and updating posteriors we leave to future work.

<sup>34</sup>In terms of the Poole (1970) optimal choice of monetary policy instrument, it is clear that for sufficiently large shocks to the supply side of the financial system, the standard assignment may be reversed.

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

### 5.3 The Augmented Rule and the Economy

The impulse responses when this augmented rule ( $\phi_m = 1$ ) is used are shown in Figures 10 and 11. 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.<sup>35</sup> Figure 10 shows that with a positive collateral shock and the benchmark rule there is an increase in consumption, 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 11, the effect is to better stabilise the economy with smaller consumption, real wage and inflation deviations. Again the smaller increase in good sector employment means that capital does not become 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 recent years when financial spreads narrowed as money and credit became more ample. The role of money to both originate as well as reflect or amplify shocks is 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 analysed how a standard inflation targeting rule is altered in the presence of a credit channel. 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 Goodfriend and McCallum (2007).<sup>36</sup> We establish the pivotal role of the external finance premium. While 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 coming through collateral and the costs of monitoring a loan

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<sup>35</sup>The results for shocks to productivity and velocity are available on request.

<sup>36</sup>In some sense we follow the second conjecture of Christiano *et al* (2007).

portfolio.<sup>37</sup> In these circumstances if the Central Bank responds in some measure to movements in money and the external finance premium, a much greater degree of control of inflation can be achieved.

We have not necessarily captured all of the features of the present crisis since 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 the current crisis by a finance premium internal to the financial system.<sup>38</sup> A model that captures this additional financing premium would still lead to similar results 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.

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<sup>37</sup>Lown and Morgan, 2006, report that the loan officer surveys do have significant exogenous information for business cycle.

<sup>38</sup>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.

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# Model Appendix

## A The Linearised Model

The model<sup>39</sup> is composed of the following linearised equations.<sup>40</sup>

Supply of Labour:

$$\frac{n}{(1-n-m)}\hat{n}_t + \frac{m}{(1-n-m)}\hat{m}_t - \hat{\lambda}_t - \hat{w}_t = 0 \quad (\text{A1})$$

Demand for Labour:

$$\hat{m}_t + \hat{w}_t + \frac{(1-\alpha)c}{mw} \left( \hat{c}_t + \frac{\phi}{\lambda} \hat{\lambda}_t \right) = 0 \quad (\text{A2})$$

Supply of Banking Services<sup>41</sup>:

$$\begin{aligned} \hat{c}_t = & \hat{v}_t c + (1-\alpha)(a2_t + \hat{m}_t) + \\ & \alpha \left[ \frac{bc}{bc + (1+\gamma)kK} (\hat{c}_t + \hat{b}_t) + \frac{kK(1+\gamma)}{bc + (1+\gamma)kK} (a3_t + \hat{q}_t) \right] \end{aligned} \quad (\text{A3})$$

reported in the main text as:

$$\hat{c}_t = \left\{ \begin{array}{l} \hat{v}_t c + (1-\alpha)(\hat{m}_t + a2_t) + \\ \alpha \left[ \frac{b}{b+k_1} \hat{b}_t + \frac{k_1}{b+k_1} (\hat{q}_t + a3_t) \right] \end{array} \right\} \left( \frac{b+k_1}{b(1-\alpha)+k_1} \right). \quad (\text{40})$$

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

CIA constraint:

$$\hat{c}_t + \hat{P}_t = \hat{H}_t + \hat{v}_t \quad (\text{A4})$$

Aggregate Supply:

$$\hat{c}_t = (1-\eta) \left( 1 + \frac{\delta K}{c} \right) (a1_t + \hat{n}_t) - \frac{\delta K}{c} \hat{q}_t \quad (\text{A6})$$

Marginal cost:

$$\widehat{mc}_t = \hat{n}_t + \hat{w}_t - \hat{c}_t \quad (\text{A7})$$

Mark-up:

$$\widehat{mc}_t = \hat{\xi}_t - \hat{\lambda}_t \quad (\text{A8})$$

Inflation:

$$\hat{\pi}_t = \hat{p}_t - \hat{p}_{t-1} \quad (\text{A9})$$

Calvo pricing:

$$\hat{\pi}_t = \kappa \widehat{mc}_t + \beta E_t \hat{\pi}_{t+1} + u_t \quad (\text{A10})$$

<sup>39</sup>The full derivation of the first-order conditions and their log-linear formulation are described in section A of the Technical Appendix, available on request.

<sup>40</sup>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 gmvdrr.m.

<sup>41</sup>The relationship is derived by setting  $b = \frac{B}{P(1+R^B)c}$ .

Marginal Value of Collateralised Lending:

$$\widehat{\Omega}_t = \frac{kK}{bc + kK} (\widehat{c}_t - \widehat{q}_t - a3_t) - \frac{bc}{bc + kK} \widehat{b}_t \quad (\text{A11})$$

reported in the main text as:

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

where  $k_2 = \frac{kK}{c}$ .

Asset Pricing<sup>42</sup>:

$$\begin{aligned} \widehat{q}_t \left[ 1 - k\Omega \left( \frac{\phi}{c\lambda} - 1 \right) \right] &= \left[ \frac{\beta(1-\delta)}{1+\gamma} + \frac{\beta\eta mc}{1+\gamma} \left( \frac{n}{K} \right)^{1-\eta} \right] \left( E_t \widehat{\lambda}_{t+1} - \widehat{\lambda}_t \right) + \frac{\beta(1-\delta)}{1+\gamma} E_t \widehat{q}_{t+1} + \\ &\frac{k\Omega\phi}{c\lambda} \left( -\widehat{c}_t - \widehat{\lambda}_t \right) + k\Omega \left( \frac{\phi}{c\lambda} - 1 \right) \left( \widehat{\Omega}_t + a3_t \right) + \\ &\left( \frac{\beta\eta mc}{1+\gamma} \left( \frac{n}{K} \right)^{1-\eta} \right) E_t \left[ \widehat{m}c_{t+1} + (1-\eta) (\widehat{n}_{t+1} + a1_{t+1}) \right] \end{aligned} \quad (\text{A12})$$

reported in the main text as:

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

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

Government Budget Constraint<sup>43</sup>:

$$T\widehat{T}_t = H \left( \widehat{H}_t - \widehat{H}_{t-1} \right) + cb\widehat{b}_t - cb(1+R^B) \left( \widehat{b}_{t-1} - \widehat{\pi}_t + \widehat{R}_{t-1}^B \right) \quad (\text{A13})$$

Bond Holding:

$$\widehat{b}_t = \varepsilon_t \quad (\text{A14})$$

Riskless Interest Rate:

$$\widehat{R}_t^T = \widehat{\lambda}_t + E_t \widehat{\pi}_{t+1} - E_t \widehat{\lambda}_{t+1} \quad (\text{A15})$$

Liquidity Service of Bonds<sup>44</sup>:

$$\frac{1+R^B}{1+R^T} \left( \widehat{R}_t^B - \widehat{R}_t^T \right) = \frac{\phi\Omega}{c\lambda} \left( \widehat{c}_t + \widehat{\lambda}_t \right) - \left( \frac{\phi}{c\lambda} - 1 \right) \Omega \widehat{\Omega}_t \quad (\text{A16})$$

<sup>42</sup>Note that in steady-state  $\frac{\xi}{\lambda} = mc$  and  $\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{1+\gamma}$ .

<sup>43</sup>We define the percentage deviation from steady state of flow and stock variables by  $\ln x_t - \ln x$ , while 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 the approximation comes from first-order Taylor expansion:  $e^x \approx 1 + x$ , while for rate variable:  $\widehat{R}_t \approx \ln(1 + R_t) - \ln(1 + R)$  and for ratio:  $\widehat{r}_t = r_t - r = \ln(x_t/y_t) - \ln(x/y) = \widehat{x}_t - \widehat{y}_t$ .

<sup>44</sup>Log-linearisation of interest rate is defined as difference from steady state:  $R_t = R + \widehat{R}_t$ .

External Finance Premium:

$$\widehat{EFP}_t = \widehat{v}_t + \widehat{w}_t + \widehat{m}_t - \widehat{c}_t \quad (\text{A17})$$

Other Interest Rates:

$$\widehat{R}_t = \widehat{R}_t^T - \widehat{EFP}_t \quad (\text{A18})$$

$$\widehat{R}_t^L = \widehat{R}_t + \widehat{EFP}_t \quad (\text{A19})$$

$$\widehat{R}_t^D = \widehat{R}_t \quad (\text{A20})$$

Policy Feedback Rule:

$$\widehat{R}_t = \phi_\pi \widehat{\pi}_t + \epsilon_t \quad (\text{A21})$$

Velocity:

$$\widehat{v}_t = v_t \quad (\text{A22})$$

For notational convenience the relevant log-linearised equations with variables denoting deviation from steady-state are reported in the main text without  $\widehat{\phantom{x}}$ .

We consider contemporaneous shocks to  $a1, a2, a3, v$ . The benchmark model has 20 endogenous variables  $\{c, n, m, w, q, P, \pi, mc, H, b, \Omega, EFP, R^T, R^B, R, R^L, R^D, \lambda, \xi, T\}$ , 5 lagged variables  $\{P_{-1}, H_{-1}, c_{-1}, b_{-1}, R_{-1}^B\}$  and 7 exogenous shocks  $\{a1, a2, a3, \varepsilon, \epsilon, v, u\}$ . The equations (A1) through (A22), 5 lagged identities construct the model to be solved by King and Watson (1998) algorithm. To obtain the simulated series we have produced 10,000 draws for the shocks from a normal distribution and plotted the middle 100 time units. Table 1 provides a complete list of the endogenous and exogenous variables of the model and their meaning. Parametrisation can be changed in gmsys.m. Steady state of transfer level, Lagrangian of production constraint and base money depend on above parameters.

## B Steady-States

From the first-order conditions derived in the Technical Appendix (pp.1-5), we show here the steady-states. For the productivity and monitoring shocks we assume a trend growth rate equal to  $A2_t = A1_t = (1 + \gamma)^t$ . In steady state  $q = 1$ ,  $A2 = A1 = (1 + \gamma)$ ,  $\lambda$  shrinks at rate  $\gamma$  so  $\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{(1+\gamma)}$  and there is no inflation so  $P = P^A = 1$  while  $K$  is constant.

$$\Omega = \frac{\alpha}{\left(\frac{b}{c} + \frac{kqK}{c}\right)} \quad (\text{41})$$

$$\frac{1 - \phi}{1 - n - m} = w\lambda \quad (\text{42})$$

$$w = \left(\frac{\phi}{c\lambda} - 1\right) \frac{(1 - \alpha)c}{m} \quad (\text{43})$$

$$w = \frac{\theta - 1}{\theta} (1 - \eta) \left(\frac{K}{n}\right)^\eta \quad (\text{44})$$

$$mc = \frac{\theta - 1}{\theta} \quad (45)$$

$$\begin{aligned} \left(\frac{\phi}{c\lambda} - 1\right)\Omega kq + \frac{1}{1+\gamma}q(1-\delta)\beta - q + E_t\beta\eta \left[ \frac{1}{1+\gamma} \frac{\xi}{\lambda} \left(\frac{n}{K}\right)^{1-\eta} \right] &= 0 \\ \left(\frac{\phi}{c\lambda} - 1\right)\Omega kq - 1 + \frac{\beta}{1+\gamma} \left[ (1-\delta) + \eta \frac{\theta-1}{\theta} \left(\frac{n}{K}\right)^{1-\eta} \right] &= 0 \end{aligned} \quad (46)$$

$$1 = \left(\frac{K}{c}\right)^\eta \left(\frac{n}{c}\right)^{1-\eta} - \frac{\delta K}{c} \quad (47)$$

$$T = -R^B \tilde{b} \quad (48)$$

where  $\tilde{b}$  is steady state debt-to-output ratio in calibration.

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Table 1 The Variables in Goodfriend and McCallum (2007)

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$c$ :	Real consumption
$n$ :	Labour input
$m$ :	Labour input for loan monitoring, or ‘banking employment’
$w$ :	Real wage
$q$ :	Price of capital goods
$P$ :	Price level
$P^A$ :	Aggregate price level
$\pi$ :	Inflation
$mc$ :	Marginal cost
$H$ :	Base money
$b$ :	Real bond holding
$\Omega$ :	Marginal value of collateral
$EFP$ :	External Finance Premium ( $R^T - R$ )
$LP^B$	Liquidity Premium on Bonds
$LP^K$	Liquidity Premium on Capital ( $kLP^B$ )
$R^T$ :	Benchmark risk free rate
$R^B$ :	Interest rate for bond
$R$ :	Policy rate
$R^L$ :	Loan rate
$R^D$ :	Deposit rate
$\lambda$ :	Lagrangian for budget constraint (shadow value of consumption)
$\xi$ :	Lagrangian for production constraint
$T$ :	Real lump-sum transfer

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Table 2 Calibration		
Parameter	Description	Value
$\beta$	Discount factor	0.99
$\kappa$	Slope of Phillips curve	0.05
$\alpha$	Collateral share of loan production	0.65
$\phi$	Consumption weight in utility	0.4
$\eta$	Capital share of firm production	0.36
$\delta$	Depreciation rate of capital	0.025
$\gamma$	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
$\theta$	Elasticity of substitution of differentiated goods	11
$\phi_{\pi}^T$	Response to inflation with inflation targeting	50
$\phi_{\pi}$	Response to inflation	1.5
$\phi_y$	Response to output	0.5
$\phi_q$	Response to asset price growth	0.5
$\rho$	Smoothing parameter in the feedback rule	0.8
Steady-States		
	Description	
$R^T$	Steady state of benchmark risk free rate	0.015
$n$	Steady state of labour 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
$\tilde{b}$	Steady state level of bond holding	0.56
$c$	Steady state of consumption	0.8409
$w$	Steady state of real wage	1.9494
$\lambda$	Steady state of shadow value of consumption	0.457
$v$	Steady state level of velocity	0.31
$\Omega$	Steady state of marginal value of collateral	0.237
$K$	Steady state of Capital	9.19

Table 3. Calibration of exogenous shocks

Description	Value	Source
<b>Persistence</b>		
$\rho_{a1}$ productivity shocks	0.95	King (2002)
$\rho_{a2}$ banking productivity shocks	0.95	Goodfriend and McCallum (2007)
$\rho_{a3}$ collateral shocks	0.9	Goodfriend and McCallum (2007)
$\rho_{\epsilon}$ monetary policy shocks	0.3	King (2002)
$\rho_u$ mark-up shocks	0.74	Smets and Wouters (2007)
$\rho_{\varepsilon}$ government debt shocks	0.9	Chadha and Nolan (2007)
$\rho_v$ velocity shocks	0.33	King (2002)
<b>Volatility</b>		
$\sigma_{a1}$ productivity shocks	0.72%	King (2002)
$\sigma_{a2}$ banking productivity shocks	1.00%	Goodfriend and McCallum (2007)
$\sigma_{a3}$ collateral shocks	1.00%	Goodfriend and McCallum (2007)
$\sigma_{\epsilon}$ monetary policy shocks	0.82%	King (2002)
$\sigma_u$ mark-up shocks	0.11%	Smets and Wouters (2007)
$\sigma_{\varepsilon}$ government debt shocks	1.00%	Chadha and Nolan (2007)
$\sigma_v$ velocity shocks	1.00%	King (2002)

Table 4. **The Information Content of Money for Output and Inflation:  
Robust Regressions on Simulated Data**

	$t - 4$	$t - 3$	$t - 2$	$t - 1$	$t = 0$	$t + 1$	$t + 2$	$t + 3$	$t + 4$	$\Sigma$	$F$
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-test tests for joint significance of the coefficients using White heteroscedastic consistent standard errors from 500 random draws from the initial simulation of 10,000.

**Table 5. The Information Content of Money**

Shock	Sign Shock	Money	EFP	Info
productivity	+	+	+	×
monitoring	+	+	-	√
collateral	+	+	-	√
monetary policy	+	+	+	×
mark-up	+	-	-	×
government debt	+	+	-	√
velocity	+	-	-	×

Note: The direction of response is denoted here in qualitative terms from the impulse response analysis shown in Figures 3-6 for productivity, monitoring, collateral and velocity shocks.

Table 6. **Correlation between Money, Inflation and the EFP**

<b>Simple inflation-targeting policy rule</b>								
Benchmark Shocks					Banking Shocks Dominant			
	$D_t$	$\pi_t$	$c_t$	$EFP_t$	$D_t$	$\pi_t$	$c_t$	$EFP_t$
$D_t$	1.34%	-0.59	0.69	0.59	1.63%	0.20	0.66	-0.21
$\pi_t$		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%

  

<b>Augmented policy rule</b>								
Benchmark Shocks					Banking Shocks Dominant			
	$D_t$	$\pi_t$	$c_t$	$EFP_t$	$D_t$	$\pi_t$	$c_t$	$EFP_t$
$D_t$	1.37%	-0.88	0.71	0.64	1.41%	-0.89	0.72	-0.046
$\pi_t$		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 off diagonal cells.  $D_t$  denotes deposits,  $\pi_t$  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.