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INSIDE MONEY IN GENERAL EQUILIBRIUM: DOES IT MATTER FOR MONETARY POLICY?

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This paper analyzes the role and importance of "inside" money, made out of commercial banks' liabilities, for a New Keynesian model of the type commonly used for monetary policy analysis. The active role of inside money stems from its unique role in allowing payment for at least some consumption goods; shocks to the production of inside money may therefore have real effects. A calibrated version of the model is shown to generate small, but nonnegligible effects of inside money shocks on output and inflation. Moreover, the presence of inside money in the model leads to a slight attenuation of the effect of technology and monetary policy shocks. Finally, it is found that it is optimal for monetary policy to react to inside money shocks, but reacting to inflation alone does not result in a significant loss of household welfare.

Keywords: Endogenous Money, Inside Money, Monetary Policy, Dynamic General Equilibrium Models, Deposit in Advance Constraint

> Central banks generally see broad money as passive, responding to the economic weather, not making it.
>
> —*The Economist*, 9 June 2007

1. INTRODUCTION

In monetary economics, a clear distinction is often made between *inside* money, which is, in a modern financial system, not under the direct control of the central bank or any other government authority, and *outside* money, which is a net asset for the private sector. Inside money is essentially a form of private credit that is therefore in zero net supply in the private sector [Lagos (2008)]. Inside money is created mainly, although not exclusively, by commercial banks and cannot be produced in excess of the preferences of the public; see, e.g., Goodhart (2007).

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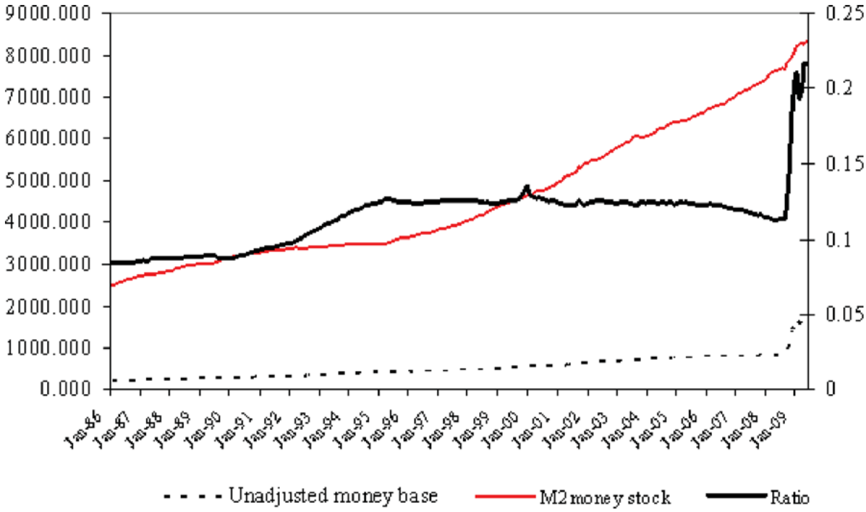

FIGURE 1. Money base and M2 money stock in the United States (left axis), seasonally adjusted and in USD billions, and ratio between the two variables (right axis). *Source:* Federal Reserve Bank of St. Louis, FRED database.

Government-produced money, in contrast, may create spending power in excess of the desires of the public (forced net saving).

In modern financial systems, inside monetary liabilities largely dominate outside money in terms of size and importance for economic transactions. Figure 1 gives an idea of how dominant inside monetary liabilities are, as the adjusted monetary base in the United States is only about 10% of the overall money stock M2 in normal times (it has gone up significantly during the financial crisis). However, models routinely used for monetary policy analysis still predominantly refer to money as outside, government-created money and therefore leave out the bulk of the economy's means of payment.[1] More recently, several papers have found significant evidence of an independent explanatory role for *broad* (hence mainly inside) monetary aggregates in empirical aggregate demand (IS curve) relationships; the latest in the series are, for example, Hafer et al. (2006) and Favara and Giordani (2009).[2]

Against this background, the objective of this paper is to introduce inside money into a standard New Keynesian model used for monetary policy analysis, in a way that appears to be the most straightforward and consistent with the empirical evidence. The objective of the analysis is to shed light on three key questions: (i) Is inside money causally active? (ii) Does the presence of inside money in the model affect the transmission of key shocks (technology and monetary policy)? (iii) How does the presence of inside money affect the optimal conduct of monetary policy? In particular, should monetary policy react to inside money (supply and demand) shocks?

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On the first question, mainstream monetary economics has by and large endorsed a passive view of inside money, implying that although inside money exists, it is completely recursive in structural models.[3] On the other hand, some economists, such as Laidler (1999, 2006), have emphasized the possibility of an active role for inside money. Laidler (1999) distinguishes several cases, and identifies the presence (absence) of nonmonetary liabilities on the liabilities side of the balance sheet of commercial banks as a key requirement for inside money to play a passive (active) role in the economy. In the absence of nonmonetary liabilities, shocks to the availability of broad money may influence the supply of loans to the private sector through a balance sheet identity, and if loans are a special form of financing, inside money demand shocks may have significant aggregate implications for output, consumption, and investment. This argument is developed in more detail in Hartley and Walsh (1991) and Hartley (1998), and was used more recently in Christiano et al. (2003) and Goodfriend and McCallum (2007). The problem with this argument, however, is that in modern financial systems banks *do* have a significant amount of nonmonetary liabilities in their balance sheet; these nonmonetary liabilities actually played a fundamental role in the global financial crisis of 2007–2009.

The nonrecursive, causally active role of inside money in the general equilibrium model of this paper does not stem from the absence of bank nonmonetary liabilities, but from the existence of a deposit-in-advance constraint, which requires part of consumption expenditure to be financed out of bank deposits. This appears to be a more realistic assumption than the absence of nonmonetary liabilities on banks' balance sheets, even in highly developed financial systems such as in the United States. Because bank deposits provide a *liquidity service* to bank customers [in the meaning of, e.g., Barnett (1980)], which is costly to supply, bank deposits are remunerated at below-market rates, a feature that is also very realistic.

An inside money demand shock is defined as an unexpected change in the tightness of the deposit-in-advance constraint, reflecting for example changes in the payments technology and in particular in banks' ability to mobilize nonmonetary assets or changes in tastes by consumers. A money supply shock is an unexpected change in the conditions under which banks provide monetary services to the customers and is reflected in a change in the spread between the interest paid on bank deposits and the prevailing market interest rate. Although the money supply shock originates exclusively in the banking sector, the money demand shock may also (and arguably mainly) originate in the household sector.

Turning to the second question addressed in this paper, we find that the presence of inside money, and in particular the existence of deposit adjustment costs, has a dampening effect on the transmission of technology and monetary shocks, although the quantitative importance of this attenuating influence is not substantial in the calibration presented in the paper.

Finally, the existence of frictions related to the existence of inside money, and notably the presence of deposit adjustment costs, might give monetary policy an additional target on top of the traditional one of stabilizing the price level in order to minimize the distortions associated with the existence of sticky prices. In other words, monetary policy might find of desirable to stabilize the spread between the nominal interest rate and the interest rate paid on inside money, in order to ensure a smooth provision of (inside) liquidity in the economy. I find, however, that this goal can largely be accomplished just by reacting to inflation to ensure determinancy; although I find it optimal to react to inside money demand and supply shocks, the optimal reaction is very small, which suggests that omitting any reaction is immaterial for household welfare. I therefore conclude that the presence of inside money does not materially affect the optimal conduct of monetary policy; in this domain, my results are similar to those obtained by Schmitt-Grohé and Uribe (2006).

It is useful to compare this paper with Goodfriend and McCallum (2007). The two papers are very much in the same spirit, as they aim at giving a structural role to banking in a New Keynesian model used for monetary policy analysis and, crucially, at evaluating the plausible quantitative importance of banking frictions for this type of models. At the same time, there are three important differences. First and foremost, the focus of the present paper is on the liabilities side of the balance sheet of banks, whereas Goodfriend and McCallum focus on the asset side. Second, as noted, I allow for the existence of bank nonmonetary liabilities, whereas Goodfriend and McCallum do not. Finally, in Goodfriend and McCallum, there is no investment, whereas in the present paper, investment is fully endogenous.

The paper is organized as follows. In Section 2 we present the model, and in Section 3 the calibration. Impulse responses, the analysis of the results, and a sensitivity analysis are in Section 4. Section 5 concludes.

2. THE MODEL

There are five types of agents in the model: a representative household, a representative final good producer, a continuum of intermediate goods producers, a financial intermediary, and the monetary authority. The government is assumed to play a completely passive role and just balance its books. The focus and main innovative element of the paper is the modeling of the financial intermediary and in particular the determination and function of inside money in the liabilities side of its balance sheet.

Because I consider aggregate sectors, there is no household debt in the model; the representative household is actually a net creditor of the banking sector in the steady state and, indirectly, of the intermediate goods–producing firms. This is in line with the prevailing situation in most industrialized countries.

Investment is endogenous in the model, as, for example, in Casares and McCallum (2000) and Ellison and Scott (2000). Although capital accumulation in itself does not play a pivotal role in the model, we follow King and Rebelo (2000) in emphasizing that including capital in the model is an essential prerequisite for any realistic representation of the supply side of the model.

The main actions and the timing in the model can be described succinctly as follows. At the beginning of each period t, the representative household lends deposits and bank bonds to the financial intermediary, who subsequently makes loans to intermediate goods–producing firms; this setup is similar to previous paper in the literature, such as Chari et al. (1995). Banks can also conduct open market operations with the central bank, at a price (interest rate) decided by the latter, in which they exchange bonds for high-powered money.[4] Nonfinancial firms produce goods and pay out a wage and dividends to households as, respectively, a remuneration for their work effort and a compensation as firm shareholders. During this time interval, the household sector consumes and provides work effort. At the beginning of the subsequent period $t + 1$, firms pay back the loan to the financial intermediary, the financial intermediary pays back deposits and bank bonds to the household sector, and the whole cycle starts again.

2.1. Households

A representative household derives utility from consumption. Consumption, c_t, is financed out of labor income and previously accumulated financial wealth. The budget constraint of the household can be written as follows:

$$P_t c_t + D_t + B_t = W_t n_t + D_{t-1} R^D_{t-1} + B_{t-1} R_{t-1} + G_t, \quad (1)$$

where P_t is the price level, D_t is one-period deposits (inside money), W_t is the nominal wage, n_t is hours worked, B_t is one-period bonds (issued by the financial intermediary[5]), R_t is the (risk-free) gross rate of return on bonds, R^d_t is the corresponding concept for deposits, and G_t represents dividends paid by intermediate goods producing firms.

Writing the budget constraint (1) in real terms leads to

$$c_t + b_t + d_t = w_t n_t + \frac{d_{t-1} R^d_{t-1}}{\pi_t} + \frac{b_{t-1} R_{t-1}}{\pi_t} + g_t, \quad (2)$$

where π_t is the gross inflation rate and variables in lower case letters are real rather than nominal.

In addition, the household faces a *second* constraint on this current consumption expenditure, a *deposit in advance constraint*,

$$\alpha_t P_t c_t \leq D_t, \quad (3)$$

or, in real terms,

$$\alpha_t c_t \leq d_t, \quad (4)$$

where $\alpha_t = \rho_\alpha \alpha_{t-1} + (1 - \rho_\alpha)\alpha + q_t$, with $0 < \alpha < 1$, $0 \leq \rho_\alpha < 1$ and q_t is an i.i.d. money demand shock with standard deviation σ_q.

The constraint in (4) is a central element of the model and it is useful to spend a few words on its rationale.[6] The basis for this assumption is the observation

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that most purchases can be done indifferently using currency and bank deposits, and that it is now very easy to convert bank deposit holdings into currency. In practice, D_t can be thought as an aggregate including both bank deposits and currency. Another way of explaining the assumption is that portfolio adjustment costs are *minimal* between currency and deposits, whereas they are *substantial* between deposits and other assets.[7] Thus, the parameter α can be interpreted as a measure of these costs. It is true that consumers could use credit cards to finance consumption, which do not require (unlike debit cards) the previous accumulation of bank deposits. However, there are endogenous limits on the use of credit cards, essentially because credit card debt is uncollateralized.[8] To capture the existence of means of payments other than bank deposits, such as credit cards, I assume that $\alpha < 1$. Hence, the money demand shock q_t can be interpreted as a shock in the (nonbank) private sector willingness to use bank deposits as a payments technology relative to other existing means of payment—for example, in the relative demand for those goods (e.g., nondurables) for which collateralized debt is not available.

The role of bank deposits in this economy may be characterized in the context of the analytical framework of Kiyotaki and Moore (2002), where agents face limits on their commitment to repay debt obligations, especially in a multilateral setting where the creditor does not know the credit history of the borrower.[9] Hence, financial or real assets have to be pledged to back up the commitment, which entails significant costs if portability is limited. For example, imagine the situation in a furniture shop in which the client (borrower) could, theoretically, choose to pay for a certain piece of furniture by issuing a credit to the seller (lender). If the seller has doubts on the willingness or ability of the client to repay, he might want to ask the client to pledge a financial asset, say a bond. If producing the bond at short notice entails a fixed cost for the client, it could be impossible to close the deal, which implies that the trade does not take place even if both agents could gain from it. This type of problem may explain the existence of special institutions, banks, which are most efficient in producing *portable* assets, i.e., deposits. In essence, banks are able to produce a commitment technology that allows them to issue "saleable paper" against "nonsaleable" paper on the assets side, using the language of Kiyotaki and Moore. This is what these authors refer to as inside money, denoted by D_t in this paper. What is important to note is that the production of this "portability" service is overwhelmingly private in financially developed economies, unlike which is typically assumed in almost all New Keynesian monetary models used for monetary policy analysis.

The household acts so as to maximize a discounted sum of expected utilities,

$$E_t \sum_{j=0}^{\infty} \beta^j U_{t+j}, \tag{5}$$

where $0 < \beta < 1$ is the discount factor and U_t is the instantaneous utility function, and E_t is the expectation operator based on a full knowledge of all variables dated

t. The utility function is defined in a log linear form as

$$U_t = \ln c_t - \phi n_t - \frac{\phi_d}{2}\left(\frac{D_t - D_{t-1}}{P_t}\right)^2, \tag{6}$$

where ϕ measures the relative importance of leisure.

Note that we introduce a quadratic adjustment cost into the household utility, i.e., the term

$$\frac{\phi_d}{2}\left(\frac{D_t - D_{t-1}}{P_t}\right)^2 \tag{7}$$

with $\phi_d > 0$, which captures the observed sluggish adjustment of deposits to the desired level as typically estimated in empirical money demand models. In this specification, too large *changes* in real deposits cause an utility drop as, e.g., consumers become anxious about their deposits holdings or they have to pay a price in terms of time and effort to keep track of their deposits holdings when they are too volatile. Deposit adjustment costs are discussed more extensively elsewhere, for example, in Cooley and Quadrini (1999) and Nelson (2002).

The representative household determines the level of $\{c_t, n_t, b_t, d_t\}$ by maximizing the lifetime utility function (5) subject to the two constraints in (2) and (4).

The first-order conditions for this problem identify the choice variables $\{c_t, n_t, b_t, d_t\}$ and the two constraints (2) and (4) for the two respective Lagrange multipliers, λ_t and ξ_t, taking other variables as given:

$$\frac{1}{c_t} - \lambda_t - \xi_t \alpha_t = 0, \tag{8}$$

$$\lambda_t = \frac{\phi}{w_t}, \tag{9}$$

$$-\lambda_t + \beta R_t E_t \frac{\lambda_{t+1}}{\pi_{t+1}} = 0, \tag{10}$$

$$\beta E_t \frac{\lambda_{t+1}(R_t - R_t^d)}{\pi_{t+1}} + \phi_d\left(d_t - \frac{d_{t-1}}{\pi_t}\right) = \beta\phi_d E_t \frac{1}{\pi_{t+1}}\left(d_{t+1} - \frac{d_t}{\pi_{t+1}}\right) - \xi_t. \tag{11}$$

Moreover, the usual transversality conditions are assumed to hold. Note that the interest rate identified by equation (10), when discounted with expected inflation, is the standard consumption-CAPM (CCAPM) level of the interest rate.

It is useful to spend a few words on equation (11), because this is closely related to inside money. The left-hand side of the equation shows the marginal costs of choosing one additional unit of real deposits in terms of the utility derived from the alternative investment in bonds: these include the forgone interest rate income (which is related to the interest rate spread between the two instruments, $R_t - R_t^d$) and the marginal adjustment cost, which is assumed to exist for deposits but not for bonds. The marginal benefits are included on the right-hand side: lower future adjustment costs and the Lagrange multiplier of the deposit-in-advance constraint, i.e., the marginal benefit of relaxing the constraint.

It is also worth noting that rearranging terms in (11), we obtain

$$\left(d_t - \frac{d_{t-1}}{\pi_t}\right) = \beta E_t \frac{1}{\pi_{t+1}} \left(d_{t+1} - \frac{d_t}{\pi_{t+1}}\right) - \frac{1}{\phi_d} \left[\beta E_t \frac{\lambda_{t+1}(R_t - R_t^d)}{\pi_{t+1}} - \xi_t\right] \quad \mathbf{(12)}$$

The last term of the right-hand side of the equation,

$$\beta E_t \frac{\lambda_{t+1}\left(R_t - R_t^d\right)}{\pi_{t+1}} - \xi_t, \quad \mathbf{(13)}$$

is a theoretical inside money demand function that equates the tightness of the deposit-in-advance constraint to the present value of the forgone interest rate income. The rest of the equation is specified in a partial adjustment format in which the real change in bank deposits (inside money), $(D_t - D_{t-1})/P_t$, depends on its future values and on the deviation of the equilibrium condition in (13) from zero.

It is also useful to solve equation (12) in the zero-inflation steady state, in order to understand the nature of the *long-run* demand for inside money in this model. As shown in the Appendix, the steady state money demand equation is

$$\ln d = -\ln\left[\frac{\lambda}{\alpha} + \beta(R - R^d)\right]. \quad \mathbf{(14)}$$

Note that log real deposits depend on the Lagrange multiplier of the budget constraint and, with a negative sign, on the difference between the interest rate on bonds and the interest rate on deposits, i.e., the opportunity cost of deposits.

Finally, the stochastic discount factor is defined as

$$\psi_{t,t+1} = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \quad \mathbf{(15)}$$

from the household budget constraint in (2).

2.2. Firms

Generally, this part of the model is relatively standard; the only element that is worth noting is the assumption that intermediate goods–producing firms have to borrow short-term from the financial intermediary to obtain resources for paying the wage bill and invest. We assume that, because of high agency costs, firms cannot retain any own funds and pay out all their profits in dividends; this could be motivated by the fact that otherwise profits would be stolen or otherwise appropriated by managers.[10] Note that firms own physical capital and, given that the value of capital is considerably higher than short-term borrowing in the steady state, do not have to explicitly put up collateral upfront.

Final goods producer. The representative final goods producer is defined in the standard way as a perfectly competitive firm, purchasing $y_t(z)$ units of each intermediate good z at a price $P_t(z)$. The final good is aggregated in the customary way as

$$y_t = \left(\int_0^1 y_t(z)^{\frac{\mu-1}{\mu}} dz \right)^{\frac{\mu}{\mu-1}}, \tag{16}$$

where μ is the demand elasticity for each intermediate good. The demand equation for each intermediate good that maximizes the final goods producer's profits is

$$y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\mu} y_t \tag{17}$$

and the aggregate price index is defined as

$$P_t = \left(\int_0^1 P_t(z)^{1-\mu} dz \right)^{-\frac{1}{1-\mu}}. \tag{18}$$

Intermediate goods producers. There is a continuum of monopolistically competitive producers of differentiated goods, indexed by z, each of which hires (homogeneous) labor ($n_t(z)$) from households. Because workers must be paid in advance of production, firms need to borrow the wage bill from the financial intermediary. Moreover, firms also need to borrow in order to invest in buying new capital goods. Because the interest payments are assumed to be linked to the nominal interest rate, this model features a cost channel of monetary policy as in, for instance, Ravenna and Walsh (2006).[11]

Nominal loans to firm z are denoted by $L_t(z) = W_t n_t(z) + P_t i_t(z)$, where $i_t(z)$ is investment. It should be noted that there is no default from debt obligations in equilibrium, but this does not mean that all *potential* borrowers are necessarily trustworthy. We assume that some "would-be" firms that would default on their obligations are excluded ex ante from receiving credit, after some screening and monitoring activity by the financial intermediary for which the latter has to expend some costs (more on this later). As a result, only the successful applicants are given credit, and exist as firms in this economy.

Each firm has an identical Cobb–Douglas production function, defined as follows:

$$y_t(z) = A_t k_t^{\gamma}(z) n_t^{1-\gamma}(z), \tag{19}$$

where A_t is an economywide productivity shifter and $0 < \gamma < 1$. The law of motion of A_t is given by

$$A_t = \exp(\chi t + \theta_t), \tag{20}$$

where $\chi > 0$ is the rate of technical progress and θ_t is a technology shock:

$$\theta_t = \rho_\theta \theta_{t-1} + \varepsilon_{\theta t}, \tag{21}$$

with $\varepsilon_{\theta t}$ being a white noise shock with standard deviation σ_θ. In the following we will denote by y_t^k, y_t^n the respective marginal productivities of capital and labor. Real profits are given by[12]

$$g_t(z) = \frac{P_t(z)}{P_t} y_t(z) - \frac{R_{t-1}^l [W_{t-1} n_{t-1}(z) + P_{t-1} i_{t-1}(z)]}{P_t} - C_p[P_t(z)] - C_k[k_t(z)], \quad (\mathbf{22})$$

where δ is the rate of capital depreciation, so that $k_{t+1}(z) = i_t(z) + (1-\delta)k_t(z)$ and R_t^l is the per-period gross rate of return required by the financial intermediary. Hence, profits depend on the difference between sales and total costs, lagged one period, as well as on the last two terms, which denote, respectively, adjustment costs on nominal prices and on capital and which are specified as

$$C_p(P_t(z)) = \frac{\phi_p}{2} \left[\frac{P_t(z)}{P_{t-1}(z)} - 1 \right]^2 y_t(z) \quad (\mathbf{23})$$

$$C_k(k_t(z)) = \frac{\phi_k}{2} [k_t(z) - k_{t-1}(z)]^2. \quad (\mathbf{24})$$

We follow the same quadratic specification of price adjustment costs as in Rotemberg (1982), assuming a zero steady state inflation rate. We also assume quadratic adjustment costs for capital.[13] Note that factor prices, i.e., wages and the price of capital goods, are economywide costs. Also note that wage and investment costs have to be repaid one period later, given that loans by the financial intermediary have a one-period maturity.

Excluding price adjustment costs, each firm's real marginal costs, $\mathrm{rmc}_t(z)$, have the following expression (assuming that the firm discounts the future at the same rate as the representative household and taking into account that the repayment of current-period loans takes place one period later):

$$\mathrm{rmc}_t(z) = E_t \frac{\psi_{t,t+1} w_t R_t^l}{y_t^n(z) \pi_{t+1}} = \frac{R_{t-1}^l}{y_t^k(z) \pi_t} - E_t \frac{\psi_{t,t+1} R_t^l (1-\delta)}{y_{t+1}^k(z) \pi_{t+1}} + \phi_k \left(\frac{\Delta k_t(z)}{y_t^k(z)} - E_t \psi_{t,t+1} \frac{\Delta k_{t+1}(z)}{y_t^k(z)} \right), \quad (\mathbf{25})$$

where the last term is related to the presence of capital adjustment costs in the profit equation (22), with $\Delta k_t(z) = k_t(z) - k_{t-1}(z)$.

Intermediate goods firms are owned by households and their managers are assumed to transfer all dividends to households at the end of each period. As noted previously, there is no accumulation of own funds and therefore no explicit modeling of the optimal choice of net worth. Each manager actsto maximize the discounted sum of real dividends defined as in (22), i.e., $E_t \sum_{j=0}^{\infty} \psi_{t,t+j} g_{t+j}(z)$, using the same stochastic discount factor as the representative household. This leads to the following first-order conditions for labor demanded and capital:

$$w_t = E_t \frac{\psi_{t,t+1} y_t^n(z) P_t(z) \pi_{t+1}}{P_t R_t^l} \tag{26}$$

$$\frac{R_{t-1}^l}{\pi_t} + \phi_k \Delta k_t(z) = \frac{P_t(z)}{P_t} y_t^k(z) + \phi_k E_t \psi_{t,t+1} \Delta k_{t+1}(z) + E_t \frac{\psi_{t,t+1} R_t^l (1-\delta)}{\pi_{t+1}}. \tag{27}$$

Equation (27) describes the optimal accumulation of capital by firms, whereby the marginal cost of an additional unit of capital (left-hand side of the equation), given by the interest rate on the necessary investment in the previous period and by the adjustment cost term $\phi_k \Delta k_t(z)$, is equal to the marginal revenue (right-hand side of the equation) given by the increase in productivity made possible by capital accumulation, the decrease in adjustment costs in the next period, and the lower need for capital in the next period, net of capital depreciation. As regards the labor demand equation in (26), note that this adjusts marginal labor productivity in the current period by the expected gross real interest rate to be paid in period $t+1$.

Finally, because firms are identical and standard assumptions apply, it is possible to derive the aggregate behavior from the conditions derived for each individual firm. For price setting, this implies the following equation:[14]

$$\lambda_t(\pi_t - 1)\pi_t = \frac{\lambda_t}{\phi_P}(1 - \mu + \mu rmc_t) + \beta E_t \lambda_{t+1}[(\pi_{t+1} - 1)]\pi_{t+1} \frac{y_{t+1}}{y_t}. \tag{28}$$

2.3. The Financial Intermediary

A representative financial intermediary (bank) has the following budget constraint at time t:

$$L_t + M_t = B_t + D_t + \widetilde{B}_t, \tag{29}$$

where L_t is loans and M_t represents the stock of bank reserves. In this model, lending to firms is *not* constrained by deposits on the liabilities side of the balance sheet, because the financial intermediary can also issue bank bonds, B_t, and credit from the central bank, $\widetilde{B}_t$. It should be emphasized that the presence of these nonmonetary liabilities distinguishes this model from Hartley and Walsh (1991), Hartley (1998), Christiano et al. (2003), and Goodfriend and McCallum (2007), where deposits constrain the supply of loans to firms on the asset side of the balance sheet.

The *real* profits of the financial intermediary, g_t^f, are expressed as follows:

$$g_t^f = d_t + b_t + \widetilde{b}_t + \frac{m_{t-1}}{\pi_t} + l_{t-1}\frac{R_{t-1}^l}{\pi_t} - \frac{d_{t-1}R_{t-1}^d}{\pi_t} - \frac{b_{t-1}R_{t-1}}{\pi_t} - \frac{\widetilde{b}_{t-1}R_{t-1}}{\pi_t} - (1+\sigma)l_t - m_t - \frac{\omega_t d_t}{m_t}, \quad \textbf{(30)}$$

where lowercase letters denote real variables, as usual, $\widetilde{b}_t = \widetilde{B}_t/P_t$ represents (real) bonds lent to the central bank as a result of an open market operation (described in more detail in the next section), $\sigma > 0$ is a scalar, and

$$\omega_t = (1-\rho_\omega)\omega + \rho_\omega \omega_{t-1} + j_t, \quad \textbf{(31)}$$

where $\omega > 0$ is a scalar, and j_t is an i.i.d. shock with standard deviation σ_j. The shock j plays an important role in this paper because it represents an "inside money supply shock." Because the banking sector is assumed to be competitive, bank profits will be zero in equilibrium. The banker has the same discount factor as the representative household and aims at maximizing the households' utility function.

The bank's profits depend on the difference between the remuneration of the assets side of the balance sheet and the interest paid on its liabilities side. There are, however, also two additional terms, which model the *cost of financial intermediation*. The bank intermediation costs in real terms, f_t, are given by

$$f_t = \sigma l_t + \frac{\omega_t d_t}{m_t}. \quad \textbf{(32)}$$

For intermediation costs on deposits, in particular, I propose a nonlinear formulation, $\omega_t d_t/m_t$, whereby intermediation costs tend to go to zero if $m_t \to \infty$, whereas they go to infinity when $m_t \to 0$. The existence of costs for the financial intermediary to manage deposits on the liabilities side of its balance sheet can be related to the obligation to provide liquidity services to customers.[15] The ratio specification has a natural interpretation in terms of *leverage*, as the cost borne by the financial intermediary is proportional to the ratio between inside and outside money (and inside money can ultimately be seen as a claim on outside money). Obviously, the ratio specification in (32) is not to be taken literally in terms of its empirical plausibility, but it serves to convey the idea that there is a *link between inside and outside money*, because the marginal cost of issuing deposits for the bank depends on the amount of outside money (bank reserves) available on its balance sheet. This appears to be a realistic characterization of modern financial systems, in which (despite technical and institutional progress) only outside money typically retains *ultimate* payment finality. Therefore, deposits may be seen as portable financial assets guaranteeing a riskless conversion into outside money. For banks to be able to provide this conversion service to customers efficiently and credibly, it is reasonable to assume that it matters significantly if they have enough outside money in their balance sheet. One may also interpret bank reserves m_t as a sort of "down payment" that the financial intermediary has to put forward in order to be given credit (in this case, in the form of inside money) by households. As a matter of fact, in many countries a reserve requirement is still imposed, which obliges banks to hold a certain fraction of their deposit liabilities in the form of bank reserves, i.e., outside money.[16]

The financial intermediary chooses bank interest rates R_t^l, R_t^d and reserves $M_t = P_t m_t$, taking other variables in equation (30) as given. The nominal interest rate R_t, in particular, is assumed to be set by the central bank. The resulting first-order conditions respectively for lending, deposits, and bank reserves, which can be derived from simple algebra, are

$$E_t \psi_{t,t+1} \frac{R_t^l - R_t}{\pi_{t+1}} = \sigma \quad \mathbf{(33)}$$

$$E_t \psi_{t,t+1} \frac{R_t - R_t^D}{\pi_{t+1}} = \frac{\omega_t}{m_t} \quad \mathbf{(34)}$$

$$m_t = E_t \left[\frac{\omega_t d_t \pi_{t+1}}{\beta \lambda_{t+1} (R_t - 1)} \right]^{\frac{1}{2}}. \quad \mathbf{(35)}$$

Equation (33) describes the *external finance premium* for nonfinancial firms, $R_t^l - R_t$, in this economy, which, as noted, is a scalar when deflated with expected inflation. By contrast, equation (34) identifies an *inside money premium*, $R_t - R_t^d$, which is inversely related to the amount of high-powered money in circulation. Together with equation (35), which describes the demand for bank reserves, this creates an *inside money channel* for the transmission of monetary policy.

In this model, outside money can be used by the monetary authority to grease the wheels of financial intermediation. This can be seen most clearly by merging equations (34) and (11), which, neglecting terms related to deposit adjustment costs for simplicity of exposition, becomes

$$\frac{\omega_t}{m_t} = \frac{\xi_t}{\lambda_t}. \quad \mathbf{(36)}$$

The right-hand side of the equation is the relative tightness of the deposit-in-advance constraint as compared with the (future expected) budget constraint. Two observations are noteworthy. First, in the absence of portfolio adjustment costs, a shock to the relative tightness of the deposit-in-advance constraint, which can be interpreted broadly as a money demand shock, has approximately the same impact as an inside money supply shock, i.e., to ω_t, on the left-hand side. Deposit adjustment costs introduce a wedge between money demand and money supply shocks, as will be clearer later on. Second, and related to the transmission of monetary policy, a (say) reduction in outside money following a monetary contraction (namely an increase in R_t) leads to an expansion of the term on the left-hand side of the equation [and to an *increase* in the inside money premium;

see equation (35)]. Other things being equal, this leads to a rise on the right-hand side, i.e., to an increase in the relative tightness of the deposit-in-advance constraint compared with the budget constraint. In other words, purchasing liquidity services from banks becomes more expensive and this leads our representative household to economize on them. In a later section of the paper, I will show how a monetary policy shock affects the key variables in the system (such as output and inflation), depending on the existence of the inside money channel. The inside money channel can be switched off, at least in the limit, by imposing $\omega_t \to 0$.[17]

A straightforward extension of this model would be to endogenize the lending costs and link them to firms' net worth in a financial accelerator framework. This avenue is not pursued further, for two reasons. First and foremost, introducing this type of dynamics goes beyond the scope of this paper, which instead focuses on the action on the *liabilities* side of banks' balance sheets.[18] Therefore, this paper has to be seen as complementary to that of Goodfriend and McCallum (2007), where the action is on the asset side of the bank balance sheet. Second, it is also notable that there appears to be much stronger empirical evidence linking what this paper defines as the inside money premium, i.e., a spread between an interest rate tightly related to monetary policy and the rate of remuneration of broad money, with the stance of monetary policy than for simple empirical *bank-based* measures of the external finance premium. For example, Berger et al. (2008); (see in particular Table 2, p. 25) report that in the United States the long-run pass-through from money market rates to lending rates is complete, whereas it is less than complete for deposit rates. This implies that changes in the nominal interest rate have a long-term impact on the inside money premium, consistent with the model presented here, but not on the external finance premium.[19]

2.4. Monetary policy

The balance sheet of the central bank reads

$$\widetilde{B}_t = M_t, \tag{37}$$

i.e., including high-powered money on the liabilities side and bonds on the assets side. Open market operations are conducted on the *money market* with the representative bank by exchanging M_t with $\widetilde{B}_t$. Taking into account the demand for bank reserves in (35), open market operations are conducted with the objective of ensuring the desired level of the risk-free (gross) interest rate, R_t, which is given by the following policy rule with interest rate smoothing:

$$R_t = (1-\rho)\left[\frac{1}{\beta} + \varphi_\pi(\pi_t - 1)\right] + \rho R_{t-1} + \varepsilon_t^R, \tag{38}$$

where $1/\beta$ is the steady state level of this interest rate, $0 < \rho < 1$, $\varphi_\pi > 1$, and ε_t^R is a monetary policy shock. Note that at this stage I do not include the output gap

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in the rule because, in a model with a cost channel, potential output is endogenous to monetary policy.

The central bank makes a profit (seignorage) when exchanging bank reserves with bonds; we assume that the profit is passed to the Treasury, which then uses it to balance its books.[20]

2.5. Equilibrium

A competitive equilibrium is an infinite sequence $\{P_t, c_t, D_t, B_t, n_t, W_t, k_t, R_t^d, R_t^l, R_t, \widetilde{B}_t, M_t\}$ in which all agents optimize, the central bank follows the policy rule in (38), and markets clear. The economywide resource constraint reads as follows:

$$y_t = c_t + i_t + \frac{\phi_k}{2}\Delta k_t^2 + \frac{\phi_p}{2}\left(\frac{P_t}{P_{t-1}} - 1\right)^2 y_t + \frac{\omega_t d_t}{m_t} + \sigma l_t, \qquad \textbf{(39)}$$

i.e., including the (capital and price) adjustment costs for intermediate goods producers and the cost of financial intermediation.

2.6. Difference from the Standard New Keynesian Model

At this stage, it may be interesting to pause briefly to look at how the model presented in this paper departs from the standard textbook New Keynesian model. The typical presentation of that model involves (i) an intertemporal IS curve, (ii) a Phillips curve, (iii) a policy rule, and (iv) a money demand function. In the model of this paper, these correspond respectively to the equations (10), (28), (38), and (12).

For the IS curve, the main departure from the standard New Keynesian model is the fact that the multiplier of the budget constraint, λ, depends not only on the marginal utility of consumption but also on the tightness of the deposit-in-advance constraint. The Phillips curve is practically the same as in the standard model, but the firms' marginal costs also contain interest expenditures, because firms have to borrow in order to pay the wage bill. The monetary policy rule is fully standard, although I consider an extended version of the rule in Section 4.4. Finally, the (inside) money demand function also reflects, in the short term, the existence of deposit adjustment costs; moreover, even in the steady state [see equation (14)], it depends not on the level of the nominal interest rate as its opportunity cost, as is typical in textbook models, but on the spread between the market rate and the deposit rate, because inside money is remunerated.

3. CALIBRATION OF THE BASELINE MODEL

The baseline calibration of the model is conducted by choosing, as much as possible, values for the parameters that are standard in the literature, and is largely

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TABLE 1. Calibration values

Parameter	Value	Parameter	Value
β	0.995	ϕ_p	58.25
ϕ	3	ϕ_k	4
γ	0.35	ρ	0.75
δ	0.025	ρ_π	1.5
σ	0.00675	σ_R	0.0025
ω	0.0009	σ_θ	0.008
α	0.7	σ_j	0.0018
ϕ_d	10	σ_q	0.006
ρ_α	0.88	ρ_ω	0.9

based on producing key moments of the endogenous variables that are empirically realistic. Table 1 reports an overview of the calibration values.

As regards time preference, because the period in the model represents a quarter, the discount factor β is set at 0.995 to obtain an annual real interest rate of about 2%. The parameter on the utility of leisure, ϕ, is parameterized to obtain a value of n at about $\frac{1}{4}$ in the steady state. The parameter α, which captures the severity of the deposit-in-advance constraint, is set at 0.70. The ratio between M2 and private consumption in the United States has declined almost continuously in the past four decades, from approximately 1 to around 0.7. I choose a level that is closer to the value at the end of the sample period, as it should be more representative of the current situation. The depreciation rate is set at the standard value of 0.025 per quarter.

The parameter governing the spread between the bank lending rate and the interest rate on bonds, σ, is set to obtain a steady state spread $R^l - R$ in line with the historical average of the spread between the prime loan rate and the fed funds rate, similar to Goodfriend and McCallum (2007). The same reasoning is followed for selecting the parameter ω, based on a historical average spread between the fed funds rate and the own rate on M2. Given that this spread has been declining over time because of the increased presence of marketable financial instruments in M2, I restrict the same to 1995–2010, which leads to an average spread of 1.7% per annum.

The parameter ruling adjustment costs in deposits, ϕ_d, is set at 10, in line with empirical (broad) money demand models, which typically find an adjustment to equilibrium of less than 1/10 in a single quarter. The parameter driving capital adjustment costs, ϕ_k, is derived to obtain a response of investment that is several times stronger than that of consumption to a monetary policy shock, which is broadly in line with the empirical literature, but at the same time also not excessively strong. The parameters of the monetary policy rule are standard; the autocorrelation coefficient is 0.75, and the reaction to inflation is the standard value of 1.5. The steady state markup is set to 6/5, which implies a profit share of about 1/6. The price adjustment parameter, ϕ_p, is set at 58.25, which (with a steady state markup of 1.2) implies that prices are fully adjusted in about one year.[21] The standard deviation of the technology shock is set at 0.008, a typical value in the real business cycle literature.

Finally, the standard deviations of the shocks to inside money supply (σ_j) and to the monetary policy rule (σ_R), as well as the persistence of the the money supply shock (ρ_ω), are recovered from a VAR model estimated on U.S. data.[22] The autocorrelation of the technology shock is set at the standard value of 0.95. The standard deviation of the money demand shock, σ_q, and the persistence ρ_α are obtained by detrending the ratio between M2 and private consumption and estimating a simple autoregressive time series model on the detrended series.[23]

The model is simulated in DYNARE on Matlab. After the zero-inflation, non-stochastic steady state of the model is identified, a first-order approximation is computed and impulse responses to the four structural shocks in the model (technology, policy, inside money demand, inside money supply) can be reported, to which I turn in the next section.

4. RESULTS

I present the results of the analysis in three steps. In Section 4.1, I review the effect of the structural shocks in the baseline model, and in Section 4.2 I analyze an additional structural shock in a close variant of the model. In Section 4.3, I conduct a sensitivity analysis in order to shed some light on the role of some key parameters—notably related to the role of inside money—in the properties of the model. Finally, in Section 4.4, I conduct an optimal monetary policy analysis, in order to clarify whether a central bank should be responding to inside money shocks within the model.

4.1. Responses to Shocks in the Baseline Model

It is useful to start from the impact of technology and monetary policy shocks, because this can give an idea of whether the model is reasonable and consistent with conventional views on the effect of such shocks. Figure 2 reports the effect of a contractionary monetary policy shock (solid lines) and a positive technology shock (dashed lines) on eight key variables in the model, namely consumption, investment, output, inflation, the nominal interest rate, real outside money M_t/P_t, real inside money d_t, and the inside money premium $R_t - R_t^d$.

The effects of a technology shock are broadly consistent with conventional wisdom on the effects of this shock [see Dedola and Neri (2007)]; the shock increases consumption, investment, and output and reduces inflation on impact. Following a monetary policy shock, the nominal interest rate increases and outside money falls. This leads to a (slight) contraction of consumption and (more substantial) of investment and output and to a fall in inflation (note that this holds despite the presence of a cost channel of monetary policy). Of interest for the analysis in this

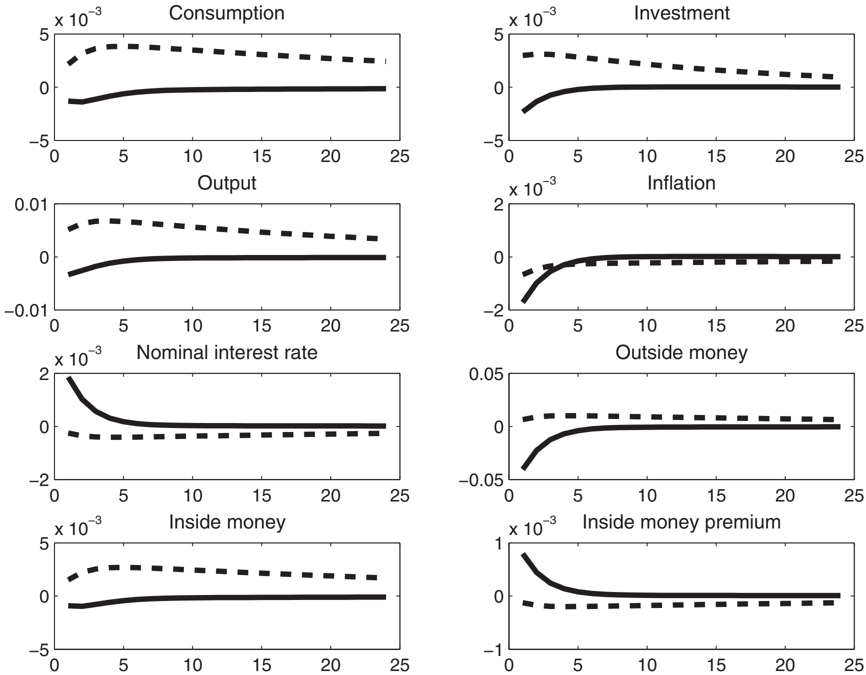

FIGURE 2. Impulse responses to a one–standard deviation monetary policy (solid line) and technology (dashed line) shock.

paper is also the *positive* impact of the interest rate shock on the inside money premium and hence on bank intermediation costs.

We now move closer to our central results and analyze the impact of inside money demand and money supply shocks, reported in Figure 3. It is useful to compare the results for inside money shocks with those obtained for outside money shocks in a standard IS–LM model as reported by, among others, Gali (1992; see in particular Figures II and III).[24] In the standard IS–LM model, a contractionary money supply shock leads to a fall in output and inflation and to a rise in the nominal interest rate; the effects of a money demand shock are exactly the mirror image of those of a money supply shock.[25]

A positive supply shock to inside money leads to a (relatively large) rise in the inside money premium and to a (slight) fall in inside money holdings. This shock essentially amounts to a rise in the *tax on consumption* represented by the inside money premium. Its effect can be decomposed into two channels. On one hand, the increase in the expenditure on liquidity services (i.e., an increase in the inside money premium) ties up resources that could otherwise be used for consumption: the representative household must therefore spend more on liquidity services and less on consumption. This has a contractionary impact that is similar to the effect of an outside money shock, although the channel is different. However, note that

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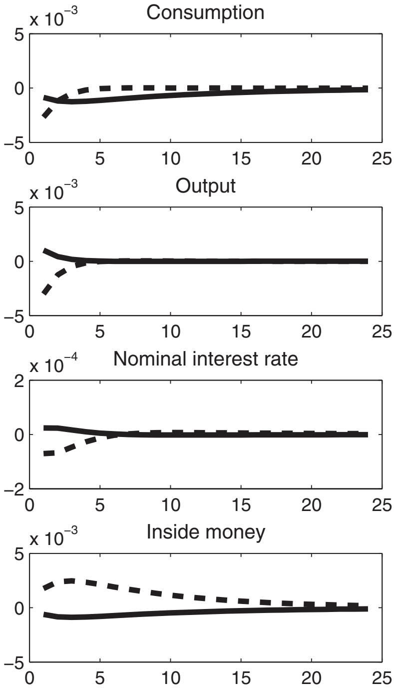

FIGURE 3. Impulse responses to a one–standard deviation inside money supply (solid line) and demand (dashed line) shock.

the reduction in consumption does not fully mirror the increase in the expenditure on liquidity services, because the household can (and in fact does) choose to work more in order to smooth consumption intertemporally. In other words, the household cushions the "loss" represented by higher costs on liquidity services partly by consuming less and partly by working more, in line with its preferences. On the other hand, in the case of the inside money shock—and unlike an outside money shock—the rise in the inside money premium translates entirely into a stronger financial intermediation activity, and because financial intermediation is a component of output (see equation (39)) in the economywide resource constraint, this is fully transmitted to output. On balance, therefore, the effect of a negative supply shock to inside money is *slightly expansionary*, i.e., the opposite of the effect of an outside money shock in a standard IS–LM model, although the effect on consumption is still contractionary. Generally, the impact of the inside money supply shock is very small.

The impact of an inside money demand shock, q_t, also reported in Figure 3, essentially represents an increase in the tax on consumption. This explains the fall in consumption. Simulations show that the lion's share of this effect is related to the presence of deposit adjustment costs, i.e., tied to the parameter ϕ_d. Therefore, the impact of the money demand shock is again *contractionary*, but this time it is in line with the conventional wisdom in the IS–LM model [see Figure III in Gali (1992)]. Note, however, that as a reaction to the shock the central bank carries out a significant injection of outside money, which offsets the impact of the inside money demand shock on the inside money premium and the financial intermediation costs, which therefore move little after the shock. Moreover, the impact of the inside money demand shock is substantially larger, notably on the nonmonetary variables, than for inside money supply shocks. The latter shock, in fact, affects the household's expenditure on liquidity services, i.e., $d_t(R_t - R_t^d)$, which in the model calibration, as in reality, is a very small part of overall consumption and economic activity. The money demand shock, in contrast, has a far greater effect, because the bulk of its effect goes through *overall* consumption expenditure. Because of the existence of deposit adjustment costs, a rise in inside money demand results in an adjustment of overall consumption, at least temporarily, and not only in the consumption of a particular good represented by liquidity services.

In conclusion, two results appear noteworthy: (i) the impact of an inside money supply shock is small and contractionary for consumption (though mechanically expansionary for output); (ii) the impact of a money demand shock is larger and contractionary.

4.2. The Effect of a Banking Distress Shock

The spread between lending rates and deposit rates can be interpreted as a measure of bank efficiency or of distance from frictionless intermediation [see also Gambacorta (2008)]. One could build on this intuition and analyze a shock to the *overall quality* of banking intermediation. To study this question, I consider a slight variant of the model, where the parameter σ driving the external finance premium becomes time-varying, as follows:

$$\sigma_t = \sigma + \omega_t - \omega. \tag{40}$$

Now, a shock to ω_t leads to a *contemporaneous* increase in the external finance premium and in the inside money premium. In other words, our bank becomes simultaneously less good (or at least less cheap) at offering liquidity services on the liabilities side of the balance sheet and at screening and monitoring lenders on the assets side. At equilibrium, this leads to a fall in the private sector demand for both bank liabilities and assets. One may be tempted to interpret this type of phenomenon in the light of the financial crisis of 2007–2009; indeed, evidence from both sides of the Atlantic has uncovered a tightening of credit extended by banks to customers (though not necessarily only reflected in a rise in lending rates) accompanied, and to some extent caused by, difficulties for banks in financing their liabilities, in particular in the interbank market. Overall, several observers have noted that the effect of the turmoil has been "as if" banks have become collectively less efficient in the intermediation process.

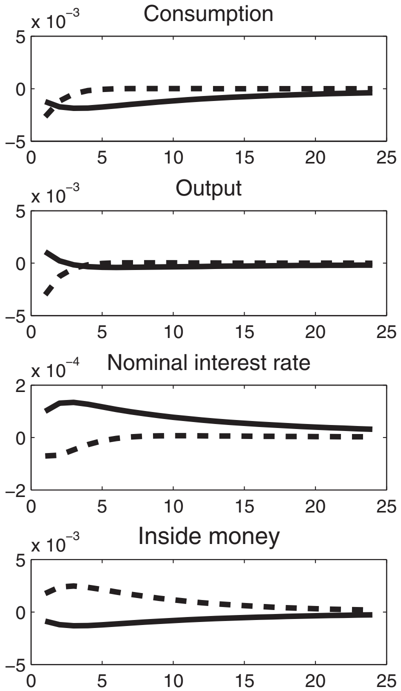

FIGURE 4. Impulse responses to a one–standard deviation "bank distress" (solid line) and inside money demand (dashed line, same as Figure 3) shock.

The impact of such as shock on the key variables in the system is reported in Figure 4. It is interesting to note that the effect of the banking distress shock ω_t (the solid line in Figure 4) is now contractionary not only for consumption but also for investment. The reason is that the increase in banking services expenditure, which determines an overall *expansionary* effect of a *negative* inside money shock, is now more strongly compensated for by the negative impact through the higher cost of external finance for firms. Still, the mechanical increase in measured banking output in the resource constraint leads to a small overall expansionary effect for output.

It should be emphasized that the modeling of the effect of banking distress in this way is excessively simplistic in terms of the features of many banking crises in the real world. For example, there is no consideration of risk, of heterogeneity among banks, or of banks' concern for regulatory capital. Even within the model, one could envisage different types of banking distress, for example, involving a partial or total gridlock of the financial flows involving the financial intermediary (i.e., deposits ceasing to be available as means of payment or interruption of the flow of short-term financing to intermediate goods–producing firms). However, it is unlikely that a more elaborated model of the banking sector would lead to

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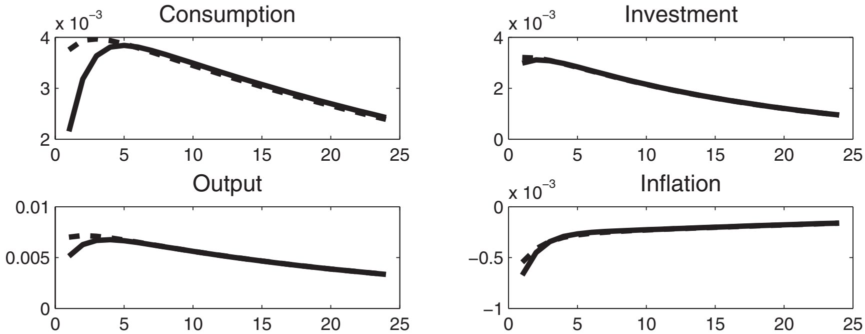

FIGURE 5. Impulse responses to a positive technology shock: baseline calibration of the model (solid line) and variant where the inside money channel is switched off (dashed line).

qualitatively different conclusions as to the key effects of bank distress on efficiency in intermediation and the spread between the remuneration on bank assets and liabilities. Moreover, the banking turmoil has clearly exposed the importance of the liabilities side of the banks' balance sheet, which is the focus of the present paper. Finally, the fact that this paper has established a link between outside and inside money may give interesting indications as to how monetary policy authorities should gear their liquidity policy amid banking turmoil, a topic that has received substantial attention since August 2007. In the impulse responses reported in Figure 4, the central bank reacts to the shock by expanding the supply of outside money, which is consistent with the generous liquidity policies followed by central banks the world over as a reaction to acute banking distress (this is also well visible in Figure 1).

4.3. Sensitivity Analysis

In this section I endeavor to clarify the role of the presence of inside money in the model in the transmission of monetary policy and technology shocks.

Figure 5 reports the impact of a positive *technology* shock on four variables, i.e. consumption, investment, output, and inflation, in the baseline case as well as in an alternative calibration where the inside money channel is practically switched off, by imposing $\phi_d = 0$ and $\alpha, \omega \approx 0$. It is evident that the inside money channel results in an *attenuation* of the effect of the shock on consumption, output, and thus inflation. The reason is again twofold: first, the positive technology shock raises optimal consumption and therefore also the consumption tax implicit in the inside money premium; second, and far more important quantitatively, the household has to incur deposit adjustment costs, which dampens the impact of the technology shock.

In Figure 6 I report the impact of a contractionary *monetary policy* shock in the baseline case (solid line) and in a variant of the model where, again, the inside money channel is switched off (dashed line). In this case deposit adjustment costs

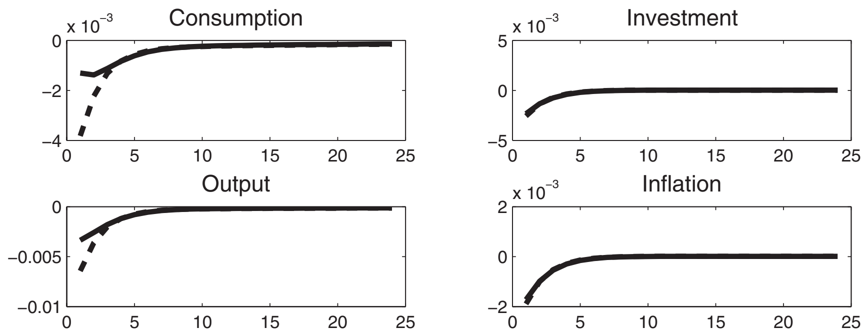

FIGURE 6. Impulse responses to a contractionary monetary policy shock: baseline calibration of the model (solid line) and variant where the inside money channel is switched off (dashed line).

have a dampening impact on consumption movements after the monetary policy shock. Moreover, the overall impact of the inside money channel as regards the effect on investment and hence output (excluding consumption) and inflation is again a dampening one, acting through the positive impact or (lack thereof) of the rise in the interest rate on financial intermediation costs in the presence (absence) of inside money in the model.

4.4. Optimal Monetary Policy

As the last step in the analysis, I endeavor to assess the importance of the inside money channel modeled in this paper for the optimal conduct of monetary policy. In particular, the presence of deposit adjustment costs raises the question of whether the monetary authority should try to stabilize the demand and supply of inside money to their equilibrium levels, in addition to trying to stabilize the price level in order to minimize the distortions associated with the fact that prices are sticky.

In this analysis we largely follow the approach of Schmitt-Grohé and Uribe (2006) and we focus on simple rules where the interest rate can react to a small number of easily observable macroeconomic variables. The objective that the central bank attempts to target is the household's expected utility, subject to a small penalty associated with interest rate volatility in order to minimize the risk of hitting the zero bound, as in Rotemberg and Woodford (1998). The optimal, simple rules presented here are the unconditionally optimal ones, i.e., irrespective of the system's initial conditions.

The monetary authority is assumed to follow a linear rule of the type

$$R_t = (1-\rho)\left(\frac{1}{\beta} + \varphi_\pi(\pi_t - 1) + \varphi_y \widehat{y}_t + \varphi_d \widehat{d}_t + \varphi_{rd} \widehat{R - R^d}_t\right) + \rho R_{t-1}, \quad \textbf{(41)}$$

where the circumflex indicates a deviation from the nonstochastic steady state levels. Note that the rule includes an indirect reaction to both inside money supply

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TABLE 2. Optimal linear policy rules

	ρ	φ_y	φ_π	φ_d	φ_{rd}
Restricted	0.00	−0.11	1.04	—	—
Unrestricted	0.00	−0.06	1.08	−0.05	0.02
Switching off the inside money channel[a]	0.00	0.05	1.02	—	—

Note: Optimization conducted in DYNARE (osr routine), based on a second-order approximation around the stochastic steady state.
[a] Approximation of the baseline model where ϕ_d, α, ω are all at one one-hundredth of their baseline value. Very low values for ω may lead to indeterminacy.

and demand shocks, because it includes both the quantity of inside money and its "price" (the inside money premium). The coefficients ρ, φ_π, φ_y, φ_d, and φ_{rd} are optimized based on a second-order approximation of the loss function in the stochastic steady state. In a restricted version of the rule, I require the φ_d and φ_{rd} coefficients to be zero; this should give us an idea of what happens to the optimal simple rule when it does not respond to inside money shocks.[26] Moreover, I also report on the optimal interest rate rule in a version of the model where the inside money channel is almost switched off (ϕ_d, α, and ω are all at one one-hundredth of their baseline values).

Table 2 reports the results. The optimal rules always feature a rather muted reaction to inflation, slightly above 1, and a negligible one to the output gap. The unrestricted optimal rule does give a role to inside money (quantity and price), but the coefficients are very small. The overall conclusion of this analysis is very much in line with Schmitt-Grohé and Uribe (2006): as long as the policy rule contains a sufficiently strong reaction to inflation (which in this model is just enough to ensure determinacy), any further improvement in terms of reaction to additional variables does not have important implications for household welfare, even with the kind of financial frictions introduced in this paper. The same conclusion holds when the inside money channel of monetary policy transmission is switched off: the optimal simple rule for this modified calibration of the model has the same characteristics as the baseline case. Overall, we conclude that the existence of inside money has rather negligible implications for the optimal conduct of monetary policy.

5. CONCLUSIONS

The main objective of this paper is to build a general equilibrium model where inside money plays a structural, causally active role. The broader question that this paper has focused on is the role of inside money in models of the DSGE type, which are typically used for monetary policy analysis.

The paper reaches five main results. First, negative inside money supply shocks are found to have a small expansionary impact on output, inflation, and interest rates, but they have a negative impact on consumption. Second, money demand shocks are found to have a more significant and contractionary impact. Third,

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the presence of inside money in the model leads to an attenuation of technology and monetary policy shocks on key variables such as consumption, output, and inflation. Fourth, simulating a situation of banking distress as a simultaneous increase in the cost of bank lending to firms and of producing deposits leads to a contraction of consumption and investment and to a rise in outside money. Finally, the inside money–related variables (inside money and the inside money premium) enter with a very small coefficient into an optimal simple linear monetary policy rule, suggesting that reacting to inside money shocks does relatively little in the way of increasing household welfare. In other words, it appears that just reacting to inflation is sufficient for stabilization purposes. Moreover, I also find that switching off the inside money channel leads to an optimal rule that is practically the same as the one identified for the baseline model.

Needless to say, the analysis may be improved in several dimensions. Two of them appear particularly promising: first, integrating the rich dynamics on the liabilities side of the banking sector in this paper with a more elaborated mechanism on the external finance premium, as for example in Goodfriend and McCallum (2007); second, estimating rather than calibrating the model.

NOTES

1. Tobin (1969) is a seminal contribution.
2. Nelson (2002) reaches similar conclusions for the monetary base. See Nelson (2003) on the role of monetary aggregates for monetary policy analysis.
3. See among others Woodford (2006).
4. Given that in the model only banks hold high-powered money, we will also refer to bank reserves interchangeably.
5. I assume for simplicity that government bonds are in zero net supply.
6. The deposit-in-advance constraint has already been introduced in previous studies; see for example Einarsson and Marquis (2001) and more recently Goodfriend and McCallum (2007).
7. For example, the banking industry has now completely automated the distribution of cash, but the liquidation of financial assets still often requires clients to physically go to the bank (or at least undertake complex transactions on the Internet).
8. See, among others, Gross and Soudeles (2002).
9. See also Kocherlakota (1998).
10. Many other papers make a similar assumption—i.e., that net worth is not enough to pay the firm's variable costs; see among others Christiano et al. (2003).
11. See Gaiotti and Secchi (2006) for empirical support for the existence of the cost channel.
12. Note that loans taken from the financial intermediary at time t are entirely passed to wage earners and used to pay investment projects; therefore, they do not appear in the profit equation of time t.
13. Cesares and McCallum (2000), among others, have argued that capital adjustment costs are likely not to be quadratic. We stick to the quadratic specification only for reasons of simplicity, in the belief that it will not matter much for the objectives of the present analysis.
14. See Keen and Wang (2007), [equation (14), p. 5], for the derivation.
15. This assumption is, of course, related to the special role played by bank deposits in eliminating information asymmetries in retail trade, as argued in Section 2.1. A deposit insurance scheme paid by the banking industry could also be a way to rationalize these costs. See Belongia and Ireland (2006) for similar considerations, and Chari et al. (1995) for a qualitatively similar formulation of the cost of producing bank deposits.

16. The importance of bank reserves for overall bank intermediation was also highlighted in the 2007–2009 global financial crisis. I will come back to this episode later in the paper.

17. Note that ω cannot be exactly zero because the transmission of monetary policy depends on its being strictly positive, even if arbitrarily small. If $\omega = 0$, then monetary policy is ineffective because bonds and bank reserves are perfect substitutes.

18. Likewise, I do not consider the role of bank capital and the possible discontinuities in bank behavior related to the existence of minimum capital requirements. See von Peter (2004) and Markovic (2008).

19. The working paper version of this paper [Stracca (2007)] contains a VAR-based empirical analysis bearing on this question.

20. If G_t is public transfers to households, T_t is taxes, and $S_t = M_{t-1}(R_{t-1} - 1)$ is seignorage income of the central bank, then we have $G_t = T_t + S_t$, and thus public sector financial flows cancel out in the household budget constraint. See Buiter (2007) for further discussion.

21. See Keen and Wang (2007, Table 1).

22. This is estimated in the working paper version of this paper; see Stracca (2007).

23. Canzoneri et al. (2007) also have a similar value for the variance of the money demand shock.

24. It should be emphasised that Gali (1992)'s model is not directly comparable to the present model; for example, his definition of money is M1 and there is no own rate on money. That is, however, precisely the focus of this comparison, namely how the present model differs from a standard, stripped-down IS–LM model.

25. See also Leeper and Roush (2003).

26. The computer code for this exercise is available upon request. I also tried a rule in which the nominal interest rate reacted to inflation in the previous period, π_{t-1}, but results were not very different.

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APPENDIX: DERIVATION OF THE STEADY STATE MONEY DEMAND FUNCTION

From (12), we have in the steady state

$$\beta \frac{\lambda(R - R^d)}{\pi} = \xi \tag{A.1}$$

and because by assumption $\pi = 1$,

$$\beta\lambda(R - R^d) = \xi. \tag{A.2}$$

From (8), we have

$$\xi = \frac{1}{c\alpha} - \frac{\lambda}{\alpha}. \tag{A.3}$$

Because $c = \frac{d}{\alpha}$,

$$\xi = \frac{1}{d} - \frac{\lambda}{\alpha}. \tag{A.4}$$

Substituting (A.4) into (A.2),

$$\frac{1}{d} = \beta\lambda(R - R^d) + \frac{\lambda}{\alpha} = 0. \tag{A.5}$$

Taking logs of both sides and multiplying by –1,

$$\ln d = -\ln\left[\frac{\lambda}{\alpha} + \beta(R - R^d)\right], \tag{A.6}$$

which is equation (14) in the main text.

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