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Abstract: This paper incorporates banks as well as frictions in the market for bank capital into a standard New Keynesian model and considers the positive and normative implications of various financial shocks. It shows that the frictions matter significantly for the effects of the shocks and the properties of optimal monetary and fiscal policy. For instance, for shocks that increase banks' demand for liquidity, optimal monetary policy accepts an output contraction while it would not in the absence of the frictions (or under suitably conducted fiscal policy). We find that optimal monetary policy can be approximated by a simple interest-rate rule targeting inflation; and it also allows large adjustments in the money supply, a property reminiscent of Poole's analysis.

JEL class: E2, E4

Keywords: Financial frictions, banking, optimal policy

Résumé : Ce papier introduit des banques, ainsi que des frictions sur le marché du capital bancaire, dans un modèle néo-keynésien standard et examine les implications positives et normatives de divers chocs financiers. Il montre que les frictions jouent un rôle significatif dans l'effet des chocs et les propriétés des politiques monétaire et budgétaire optimales. Par exemple, en réponse aux chocs qui augmentent la demande de liquidité des banques, la politique monétaire optimale autorise une contraction de l'activité, ce qu'elle ne ferait pas en l'absence de frictions (ou en présence d'une politique budgétaire optimale). Nous trouvons que la politique monétaire optimale peut être approximée par une règle de taux d'intérêt simple ciblant l'inflation et qu'elle autorise de grandes variations de l'offre de monnaie, une propriété qui rappelle l'analyse de Poole.

Codes JEL : E2, E4

Mots-clefs : Frictions financières, banques, politique optimale

1 Introduction

The recent financial crisis has drawn attention to a number of important policy questions. For instance, how should fiscal and monetary policy react to an increase in the default rate on bank loans? How are liquidity problems affecting the funding side of banks (in interbank and securities markets) transmitted to the lending side, and what is the appropriate policy response? How does a fiscal transfer (a capital infusion like the US bank bailout) affect the banks' willingness to lend as well as the central banks' menu of optimal actions?

The benchmark New Keynesian (NK) model [e.g., Woodford (2003)], the workhorse model for monetary-policy analysis, abstracts from money and banking and thus cannot be used to study such questions.[1] Nonetheless, some of them are being addressed in recent contributions. For example, Cúrdia and Woodford (2009a, c) introduce a friction (costs of financial intermediation) between lenders and borrowers but without explicitly modelling banks and characterize optimal conventional and unconventional monetary policy. Gertler and Kiyotaki (2009) develop a model of the collapse of the interbank market and consider the scope for unconventional monetary policy; they also review a number of other contributions that model a particular aspect of the crisis. Hobijn and Ravenna (2009) model the implications of asymmetric information for loan securitization. Meh and Moran (2008) introduce asymmetric information between banks and their creditors and study the business cycle implications of financial and non-financial shocks.

The objective of this paper is to develop a simple, unified framework that is capable of addressing the questions raised above. To this end, we add a banking sector as well as an explicit friction in the market for bank capital to a basic NK model and consider the positive and normative implications of three shocks: a shock that increases the default rate on bank loans, a shock

[1] Although the NK model has been recently extended to include a banking sector [e.g., Andrés and Arce (2008), Canzoneri, Cumby, Diba, and López-Salido (2008), Christiano, Motto, and Rostagno (2008), Gerali, Neri, Sessa, and Signoretti (2008), Goodfriend and McCallum (2007)]these extensions do not focus on the type of questions raised above.

that increases the demand for excess reserves, and a shock that hampers the ability of banks to securitize loans. While these shocks have allegedly played a prominent role in the recent financial crisis (and have motivated papers such as Gertler and Kiyotaki (2009) and Hobijn and Ravenna (2009)) we do not study their implications during singular events such as a crisis but rather under "standard" business cycle conditions.[2] We show how the equity market friction matters for the transmission of these shocks– and, therefore, for optimal policy responses– and how its implications may differ significantly from those obtained in standard financial macro-models that lack this feature. Consequently, to the extent that such frictions play a role in macroeconomic fluctuations, our analysis may provide useful insights about the conduct of optimal policy that go beyond those available in the literature.

Why is such a friction worth considering? Models with frictionless equity markets for bank capital may have a number of strong implications that derive from the ability of banks to recapitalize themselves easily by lowering dividend payments or, if need be, paying *negative* dividends. In such models, the lending and borrowing sides of banks become decoupled. The spread between the lending rate and the risk-free (CCAPM) rate depends on default risk but not on the liquidity shock affecting the demand for excess reserves. Moreover, a bank in such a world would never undertake costly securitization because it can always get funds at the CCAPM rate from its owners and save them the costs of securitization. Therefore, shocks to securitization do not matter in the absence of frictions in equity markets.

Furthermore, the decoupling of the lending and borrowing sides may eliminate the scope for certain types of fiscal intervention. For instance, a fiscal transfer to banks simply induces them to pay more dividends, without altering their lending or other activities.[3] This is a reflection of the Modigliani-Miller

[2]There are two reasons for this choice. First, we believe that such shocks do not always –or even often– threaten the financial system with collapse. So their study in non-crisis situations may be of independent interest. And second, accounting for the recent financial crisis would probably require the introduction of informational asymmetries, a feature that would considerably restrict the set of questions that our model could address.

[3]So, this version of our model is consistent with the views of several economists, e.g.,

theorem, and is likely to be present in any model that (implicitly or explicitly) assumes a frictionless market for bank equity.

We specify the friction in the form of dividend smoothing.[4] In this model, banks may engage in costly securitization because the alternative may be a costly adjustment of dividend payments (or costs of raising new capital). When securitization costs increase or when a liquidity shock increases the demand for excess reserves, the spread between the lending rate and the risk-free (CCAPM) rate increases, and the volume of loans falls. There is a role for fiscal policy in this case. A fiscal cash infusion reduces the spread and increases the volume of loans. Optimally conducted fiscal policy can completely liberate monetary policy from pursuing conflicting objectives, allowing the achievement of greater efficiency.

An important normative result in the extant literature is Cúrdia and Woodford's (2009a,c) finding that the presence of financial frictions and shocks does not fundamentally alter the strong policy implication of simpler NK models prescribing a flexible inflation target. Although our model is different, our conclusion about the normative case for pursuing price stability is similar. Optimal policy tolerates some (but not much) inflation variability. In response to liquidity shocks (increases in the demand for reserves or costs of securitization) it moves the policy rate very little and may allow instead a sharp increase in money growth. This finding is reminiscent of Poole's (1970) results in the context of the IS-LM model.[5] As in Poole, a policy that would restrict money growth variability would carry a large welfare cost in our model. Also, echoing similar findings in the literature we find that a simple rule reacting to inflation gets close to optimal (Ramsey) policy in terms of welfare.

In what follows, Section 2 presents our model. Section 3 presents the param-

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Mulligan (2008), who argued against the US bank-bailout plan informally, asserting that it was simply a transfer from taxpayers to the owners of banks.

[4]In the corporate finance literature, the observation that managers smooth dividends goes back to Lintner (1956). Our simple way of incorporating this motive is admittedly ad hoc, but follows the existing literature [see, for example, Jermann and Quadrini (2006) and their references].

[5]Poole pointed out that in face of shocks to the LM curve, monetary policy should keep the interest rate constant and allow the money supply to fluctuate endogenously.

eter values used for our simulations reported in Section 4. Section 5 presents results on optimal (Ramsey) policies. Section 6 contains a discussion of possible extensions and Section 7 summarizes and concludes.

2 Model

We consider an economy populated with infinitely-lived households, monopolistically competitive banks and firms producing differentiated intermediate goods, perfectly competitive firms producing the final good, and fiscal and monetary authorities. Our rendition of households and their demand for money is closely related to the standard Lucas and Stokey (1983) setup with cash goods and credit goods, often used in the normative literature [e.g., Chari, Christiano, and Kehoe (1991); Correia, Nicolini, and Teles (2008)]. To incorporate a demand for deposits in the model, we assume that the consumption good is a Cobb-Douglas aggregate over a good that can be bought with cash and a good that can be bought using deposits. We let "leisure" implicitly serve as the credit good in our model.

Each period is divided into two subperiods: a financial exchange followed by a goods exchange. In the financial exchange, after the realization of current shocks, retailers borrow from banks to buy the intermediate goods and assemble the final good to be sold to consumers, the government, and banks (in the version of the model with costly banking); households pay taxes and choose their asset portfolios, acquiring the money and deposits that they plan to use in the subsequent goods exchange; and firms producing intermediate goods pay wages and dividends with the proceeds of their sales to retailers. In the goods exchange, households use money and deposits to buy goods from the retailers that have not been hit by a default shock (those who have been hit by the shock end up not producing anything). We assume that the government buys goods with cash (although this is inconsequential for our analysis). Retailers must wait until the following financial exchange to use the cash and liquidate the deposits that they acquire; so, they are indifferent between these means of payment and set the same price for cash and deposit goods.

2.1 Households

The representative household gets utility from consumption and disutility from work:

$$U_t = E_t \left\{ \sum_{j=0}^{+\infty} \beta^j \left[\Phi \ln \left(c_{t+j}^M \right) + (1 - \Phi) \ln \left(c_{t+j}^D \right) - \frac{1}{1+\chi} h_{t+j}^{1+\chi} \right] \right\}$$

with $0 < \beta < 1$, $0 < \Phi < 1$ and $\chi > 0$, where c_t^M and c_t^D denote consumptions of cash goods and deposits goods at date t respectively, and h_t stands for hours worked (in the intermediate-goods sector).

The household's budget constraint, in real terms, is:

$$\left(\frac{1 + R_{t-1}^A}{\Pi_t} \right) a_{t-1} + \left[\left(\frac{1 + R_{t-1}^D}{\Pi_t} \right) d_{t-1} - \frac{c_{t-1}^D}{\Pi_t} \right] + \left(\frac{m_{t-1}^H}{\Pi_t} - \frac{c_{t-1}^M}{\Pi_t} \right) + w_t h_t + \pi_t^I + z_t - a_t - m_t^H - d_t - t_t \geq 0, \quad (1)$$

where $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ is the inflation rate, d_t deposits, $1 + R_t^D$ the gross nominal interest rate on deposits, m_t^H money balances held by the household, w_t wages, π_t^I the profits of firms producing intermediate goods, z_t the dividends paid by banks, and t_t a lump-sum tax. The variables are represented by a lower-case letter when expressed in real terms and by an upper-case letter when expressed in nominal terms. The asset a_t represents the household's portfolio of nominally risk-free bonds, and $1+R_t^A$ is the gross nominal CCAPM interest rate. Risk-free nominal bonds may be issued by the government or other households (although, in equilibrium, the latter will be in zero net supply). Moreover, we will treat securitization of loans by banks as issuing risk-free bonds (so, the bank incurs the default cost of securitized loans). This is just to simplify our notation; we could equivalently assume that households directly incur the default costs of securitized loans and, in equilibrium, banks would pay a higher interest rate to households who bear the default cost.

The households' optimization problem is

$$\underset{a_t, c_t^M, c_t^D, m_t^H, d_t, h_t}{Max} U_t$$

subject to the cash- and deposits-in-advance constraints

$$\begin{aligned} m_t^H - c_t^M &\geq 0, \\ d_t - c_t^D &\geq 0, \end{aligned}$$

and the budget constraint (1). The first-order conditions of this optimization problem are:

$$\begin{aligned} \frac{\Phi}{c_t^M} - \mu_t^M - \beta E_t \left\{ \frac{\lambda_{t+1}}{\Pi_{t+1}} \right\} &= 0, \\ \frac{1-\Phi}{c_t^D} - \mu_t^D - \beta E_t \left\{ \frac{\lambda_{t+1}}{\Pi_{t+1}} \right\} &= 0, \\ \mu_t^M + \beta E_t \left\{ \frac{\lambda_{t+1}}{\Pi_{t+1}} \right\} - \lambda_t &= 0, \\ \mu_t^D + \beta \left(1 + R_t^D\right) E_t \left\{ \frac{\lambda_{t+1}}{\Pi_{t+1}} \right\} - \lambda_t &= 0, \\ -h_t^{\chi} + w_t \lambda_t &= 0, \\ \beta \left(1 + R_t^A\right) E_t \left\{ \frac{\lambda_{t+1}}{\Pi_{t+1}} \right\} - \lambda_t &= 0, \end{aligned} \tag{2}$$

where λ_t is the Langrange multiplier associated with the household's budget constraint.

2.2 Intermediate goods producers

There is a unit mass of monopolistically competitive firms producing intermediate goods. Firm j operates the production function:

$$x_t(j) = h_t(j) \exp\left(z_t^p\right).$$

We assume that firms set their prices facing a Calvo-type price rigidity (with no indexation).

2.3 Final goods producers

Producers of the final good– henceforth, "retailers"– are perfectly competitive. They use $x_t(j)$ units of each intermediate good $j \in [0,1]$ to produce y_t units of the final good with

$$y_t = \left(\int_0^1 x_t(j)^{\frac{\varepsilon - 1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon - 1}}, \tag{3}$$

where $\varepsilon > 1$. Firms hit by a default shock use their inputs but don't produce any output.

Intermediate good j sells for the nominal price $P_t^X(j)$. We break the retailer's optimization problem into two parts. First, the cost minimization problem involves choosing $x_t(j)$ for all $j \in [0, 1]$ to minimize

$$\int_0^1 P_t^X(j) x_t(j) dj$$

given y_t and subject to the constraint imposed by the production function (3). This implies

$$x_t(j) = \left(\frac{P_t^X(j)}{P_t^X} \right)^{-\varepsilon} y_t, \tag{4}$$

where

$$P_t^X \equiv \left(\int_0^1 P_t^X(j)^{1-\varepsilon} \, dj \right)^{\frac{1}{1-\varepsilon}} \tag{5}$$

is the marginal (and average) cost of producing y_t.

Second, we assume that retailers must borrow from banks to buy intermediate goods:[6]

$$\frac{P_t^X}{P_t} x_t = l_t, \tag{6}$$

where P_t is the price of the final good. The zero-profit condition of retailers implies

$$P_t = \left(1 + R_t^L\right) \, P_t^X. \tag{7}$$

So, P_t is just a markup over the cost P_t^X of acquiring the goods, and the markup factor is the interest rate on loans. The zero profit condition of retailers has the following interpretation. A one-period entrant at time t could borrow L_t, buy intermediate goods and sell them for $P_t y_t$. Next period, the potential entrant would have exactly $P_t y_t = \left(1 + R_t^L\right) L_t$ to pay off the bank loan with no profit or loss.

[6] Of course, this borrowing constraint is artificially imposed in our model. Any model of costly intermediation necessarily involves artificial constraints that make agents borrow from banks, instead of borrowing from each other and saving the intermediation costs.

2.4 Banks

Banks are owned by households and have some market power in setting the interest rates on deposits and loans.[7] A bank setting the gross nominal interest rate, $1 + R_t^L$, that it charges on its loans, l_t, faces the demand curve for loans

$$l_t = \left(\frac{1 + R_t^L}{1 + \overline{R}_t^L} \right)^{-\sigma_l} \bar{l}_t \tag{8}$$

with $\sigma_l > 1$. Similarly, a bank setting the gross nominal interest rate, $1 + R_t^D$, paid on its deposits, d_t, faces

$$d_t = \left(\frac{1 + R_t^D}{1 + \overline{R}_t^D} \right)^{-\sigma_d} \overline{d}_t \tag{9}$$

with $\sigma_d > 1$. The variables with an upper bar ($\overline{d}_t$, $\bar{l}_t$, $\overline{R}_t^D$, $\overline{R}_t^L$) denote the corresponding average variables [see Gerali et. al. (2008)]. All banks are identical and set the same interest rates in a symmetric equilibrium. Banks hold reserves m_t^B to manage the liquidity of deposits:

$$m_t^B = d_t \exp(z_t^d). \tag{10}$$

The representative bank chooses z_t, a_t, m_t^B , R_t^D and R_t^L to maximize its stock-market value

$$E_t \left\{ \sum_{j=0}^{+\infty} \beta^j \lambda_{t+j} z_{t+j} \right\}$$

subject to (8), (9), (10), and the cash-flow constraint

$$\begin{aligned} z_t \quad = \quad & a_t + d_t + (1 - \delta_{t-1}) \left(\frac{1 + R_{t-1}^L}{\Pi_t} \right) l_{t-1} + \frac{1}{\Pi_t} m_{t-1}^B \\ & - \frac{\Phi_a}{2} (a_t - a_t^*)^2 - \left(\frac{1 + R_{t-1}^A}{\Pi_t} \right) a_{t-1} - \left(\frac{1 + R_{t-1}^D}{\Pi_t} \right) d_{t-1} \\ & - l_t - m_t^B - \tau_t - \frac{\Phi_z}{2} (z_t - z^*)^2 \end{aligned} \tag{11}$$

[7] The only reason we assume banks have market power is to remove the period-by-period zero-profit condition that would be implied by a perfectly competitive banking sector. We could not have random taxation (or fiscal transfers) in the banking sector while satisfying a zero-profit condition at every date. Nor could we model dividend smoothing if our banks made zero profits.

with $\Phi_a \geq 0$ and $\Phi_z \geq 0$, where δ_t is the default rate, and τ_t a tax (when positive) or transfer (when negative) financed by taxing households. To study the responses of endogenous variables to a fiscal transfer to banks, we set

$$\tau_t = \tau_{ss} - \varepsilon_t^{\tau}. \tag{12}$$

When $\Phi_a > 0$, banks face a cost of issuing an amount of securities a_t different from

$$a_t^* = a_{ss} \exp\left(-z_t^s\right),$$

where $a_{ss} > 0$ is the steady-state value of a_t and z_t^s is a shock to securitization.[8] When $\Phi_z > 0$, banks face a cost of setting dividends different from $z^* = z_{ss} > 0$, where z_{ss} is the steady-state value of z_t.

In a symmetric equilibrium, the first-order conditions of this maximization problem are:

$$\begin{aligned}
\lambda_t - \lambda_t^z \left[1 + \Phi_z \left(z_t - z^*\right)\right] &= 0, && (13) \\
\lambda_t^z \left[1 - \Phi_a \left(a_t - a_t^*\right)\right] - \beta \left(1 + R_t^A\right) E_t \left\{\frac{\lambda_{t+1}^z}{\Pi_{t+1}}\right\} &= 0, && (14) \\
\left(\frac{1 + R_t^L}{1 + R_t^A}\right) \left[1 - \Phi_a \left(a_t - a_t^*\right)\right] \left(1 - \delta_t\right) &= \frac{\sigma_l}{\sigma_l - 1}, && (15) \\
\frac{1 - \Phi_a \left(a_t - a_t^*\right)}{1 + R_t^A} &= 1 - \frac{\lambda_t^d}{\lambda_t^z}, \\
\left(\frac{1 + R_t^D}{1 + R_t^A}\right) \left[1 - \Phi_a \left(a_t - a_t^*\right)\right] &= \frac{\sigma_d}{\sigma_d + 1} \left(1 - z_t^d \frac{\lambda_t^d}{\lambda_t^z}\right),
\end{aligned}$$

where λ_t^d and λ_t^z are the Langrange multipliers associated with equations 10 and 11 respectively. Note that there is a monopoly markup on the lending rate and a monopoly "mark-down" on the deposit rate.

2.5 Government

Government purchases are exogenous and follow an AR(1) process. For concreteness, we assume that the fiscal authority uses cash to pay for its purchases,

$$m_t^G = g_t,$$

[8] Our assumption that banks issue some securities in the steady state ($a_{ss} > 0$) is not necessary but seems like a reasonable shortcut. The alternative would be to model, say, the labor costs of both deposit creation and securitization, let banks minimize their funding costs, and derive the optimal mix of deposits, securities, and equity for funding loans.

but this does not matter for our results. Since Ricardian Equivalence holds in our model, we don't need to model the dynamics of public debt explicitly.[9] We can just assume that the fiscal authority maintains a balanced budget and sets

$$t_t = g_t - \tau_t.$$

When we consider the model under a simple monetary policy rule, we will use a rule like

$$\left(1 + R_t^A\right) = \left(1 + R_{t-1}^A\right)^{\rho} \left[\left(1 + R_{ss}^A\right) \left(\frac{\Pi_t^X}{\Pi_{ss}}\right)^{\theta_m}\right]^{1-\rho} \exp\left(\varepsilon_t^m\right), \qquad (16)$$

where $\Pi_t^X \equiv \frac{P_t^X}{P_{t-1}^X}$, or the equivalent rule reacting to CPI inflation. We will compare these rules to optimal (Ramsey) policy.

2.6 Market clearing conditions

The goods market clearing condition is

$$\left(1 - \delta_t\right) y_t = c_t + g_t + \frac{\Phi_a}{2} \left(a_t - a_t^*\right)^2 + \frac{\Phi_z}{2} \left(z_t - z^*\right)^2$$

and the money market clearing condition is

$$m_t = m_t^H + m_t^B + m_t^G.$$

2.7 Shock processes

We assume that ε_t^m and ε_t^τ are white noises (with standard deviations σ_m and σ_τ) and that the other shocks follow autoregressive processes of order one:

$$\begin{aligned}
z_t^p &= \rho_p z_{t-1}^p + \varepsilon_t^p, \\
\log\left(g_t\right) &= \left(1 - \rho_g\right) \log\left(g_{ss}\right) + \rho_g \log\left(g_{t-1}\right) + \varepsilon_t^g, \\
z_t^s &= \rho_s z_{t-1}^s + \varepsilon_t^s, \\
z_t^d &= \left(1 - \rho_d\right) z_{ss}^d + \rho_d z_{t-1}^d + \varepsilon_t^d, \\
\log\left(\delta_t\right) &= \left(1 - \rho_\delta\right) \log\left(\delta_{ss}\right) + \rho_\delta \log\left(\delta_{t-1}\right) + \varepsilon_t^\delta,
\end{aligned}$$

[9] But these bonds are implicitly present because our monetary authority trades them in open market operations.

where ρ_p, ρ_g, ρ_s, ρ_d, ρ_δ are parameters between zero and one, while ε_t^p, ε_t^g, ε_t^s, ε_t^d and ε_t^δ are white noises (with standard deviations σ_p, σ_g, σ_s, σ_d and σ_δ).

2.8 Frictionless Equity Market

The special case of our model with a frictionless equity market ($\Phi_z = 0$) has a number of strong implications. In this case, (13) implies $\lambda_t = \lambda_t^z$. Then, combining (14) with (2), we see that the marginal cost of securitization is zero. If we set $a_{ss} = 0$ (so that any securitization is costly), banks will not issue any securities. Note that this implication is not due to the functional forms we assume for costs. The more general point is that banks should not undertake costly securitization if they can issue equity (freely adjust dividends), get funds at the CCAPM rate from their owners, and save the costs of securitization.

Also, in this case, (15) implies that the spread between the lending rate and the risk-free (CCAPM) rate fluctuates only in response to default shocks, and does not depend on the other shocks in our model. Moreover, in this case, the lump-sum tax or transfer τ_t has no effect, except on the banks' dividend payments z_t. All these implications of the model are removed once we allow for a friction in the equity market ($\Phi_z > 0$).

3 Parametrization

Our model has a number of parameters that are hard to calibrate. These parameter values do not play an important role for our results because our presentation will highlight either qualitative features of optimal policies or broad quantitative differences across policies, and these are not sensitive to the parameter values.[10] We set $\Phi_z = 0.25$ when we allow for dividend smoothing by banks, following Jermann and Quadrini's (2006) choice for the dividend-smoothing parameter

[10]We don't pursue quantitative results because our stylized model cannot match basic features of banking sector data anyway. For example, in US data, deposits and bank loans are three to four times the size of quarterly consumption; in our model, consumption of "deposit goods" has to be smaller than total consumption, and loans have to be about as large as output.

for firms. We also set $\Phi_a = 0.25$.[11] The default rate is 0.86 percent in the steady state (the average charge-off rate for US bank loans from 1985Q1 to 2008Q3). We set $\Phi = 0.43$ as the share of cash goods in consumption, following Chari, Christiano, and Kehoe (1991). Given this value, the model pins down the steady-state level of deposits and their share in funding bank loans.

We set a_{ss} so that banks securitize 19 percent of their loans in the steady state (the ratio of securitized consumer and real estate loans to bank credit, for US commercial banks, in August 2008). We assume bank reserves are 7.6 percent of deposits in the steady state (the ratio of aggregate reserves of depository institutions to deposits in the US in August 2008, where deposits are measured as M1 minus currency outside banks). The bank's balance sheet identity then pins down the value of z_{ss}. We set σ_d to make the interest rate on deposits 2 percent per annum. We set σ_l to make the interest rate on loans 8.4 percent per annum [so, adjusting for the default rate our Prime rate would be 5 percent per annum, close to the average Prime rate after 1980]. In our simple rule for monetary policy we set the inertia parameter to 0.8 and the (long-run) response to inflation to 1.5. Finally, we set the steady-state gross inflation rate per quarter to its optimal value, equal to 0.9996. We explain later how this value is obtained and comment upon it.

The standard deviations of our shocks to productivity and government purchases take standard values. Our shocks to the central bank's interest rate rule and our tax shock (fiscal transfer to the banking sector) are only for illustrative purposes and their size does not matter for our analysis.[12] For each shock following an AR(1) process, we set the inertia parameter equal to 0.9.

We set the standard deviation of our default shock innovation such that an increase (in the charge-off rate) of the magnitude observed during the recent

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[11] Larger values of Φ_z and Φ_a would make banks less willing to adjust dividend payments and securitization; this would make the effects of financial shocks larger under all the policies we consider below, but it would not affect the qualitative features or comparisons across policies that we will highlight.

[12] We use the estimate of the monetary policy shock in Canzoneri, Cumby and Diba (2007) and assume the tax shock has a standard deviation of one percent. But we deactivate both shocks throughout, except for using the responses to these shocks to highlight their transmission mechanisms.

financial crisis would occur on average once in 80 years in our model. In the data, the average charge-off rate from 1985Q1 to 2008Q3 was 0.86 percent; the rate grew to 2.88 percent in 2009Q3. Under our parametrization, an increase of this magnitude over 4 quarters has probability $\frac{1}{320}$, given our AR(1) process and assuming that the innovation has a Gaussian distribution.[13] So, a randomly selected quarter may be the start of a large 4-quarter increase in the default rate on average every 320 quarters or 80 years, which roughly corresponds to the time elapsed between the Great Depression and the recent crisis.

Similarly, we set the standard deviation of the reserves-demand shock innovation such that, starting from its steady-state value of 7.6 percent (the August 2008 figure), the reserves-to-deposits ratio reaches at least 107 percent (the August 2009 figure) in one year's time with probability $\frac{1}{320}$.

Finally, we set the standard deviation of the securitization shock innovation such that, starting from the steady state, a one-standard-deviation innovation reduces the zero-cost amount of securities by the same amount as a one-standard-deviation reserves-demand shock innovation increases reserves (for a constant amount of deposits). This choice will allow us to compare the effects of the two shocks under optimal policy because the two shocks have the same impact effect in terms of tightening the banks' balance sheets.

The parameter values are as follows:

[13] More precisely, the standard deviation σ_δ of the default shock innovation is set such that a variable having a Gaussian probability distribution with mean zero and variance $\sigma_\delta^2\left(1+\rho_\delta^2+\rho_\delta^4+\rho_\delta^6\right)$ exceeds $\ln(2.88)-\ln(0.86)$ with probability $\frac{1}{320}$, where $\rho_\delta = 0.9$ denotes the inertia in the default shock.

$\pi_{ss} = 0.9996$	steady-state gross inflation rate per quarter
$\delta_{ss} = 0.0086$	s.-s. default rate per quarter
$z^d_{ss} = 0.076$	s.-s. reserve ratio
$\beta = 0.99$	discount factor
$\Phi = 0.43$	share of cash goods in consumption
$\sigma = 7$	elasticity in the goods aggregator
$\sigma_d = 230$	elasticity in the deposits aggregator
$\sigma_l = 420$	elasticity in the loans aggregator
$\rho = 0.8$	degree of inertia in interest-rate rule
$\theta_m = 1.5$	coefficient on inflation in interest-rate rule
$\chi = 1$	inverse of Frisch elasticity of labor supply
$\alpha = 0.75$	probability Calvo fairy does not visit price setter
$\frac{g_{ss}}{(1-\delta_{ss})y_{ss}} = 0.25$	s.-s. share of government purchases in output
$\frac{a_{ss}}{l_{ss}} = 0.19$	s.-s. ratio of bank securities to loans
$\tau_{ss} = 0$	s.-s. lump-sum tax on banks
$\Phi_a = 0$ or 0.25	adjustment-cost parameter for securities
$\Phi_z = 0$ or 0.25	adjustment-cost parameter for dividends
$\rho_p = 0.9$	inertia in productivity shock
$\rho_g = 0.9$	inertia in government-expenditures shock
$\rho_s = 0.9$	inertia in securitization shock
$\rho_d = 0.9$	inertia in shock to demand for reserves
$\rho_\delta = 0.9$	inertia in default shock
$\sigma_p = 0.0086$	standard deviation of productivity shock innovation
$\sigma_g = 0.010$	stand. dev. of gov.-expenditures shock innovation
$\sigma_s = 0.12$	stand. dev. of securitization shock innovation
$\sigma_d = 0.56$	stand. dev. of reserves-demand shock innovation
$\sigma_\delta = 0.26$	stand. dev. of default shock innovation
$\sigma_m = 0.0024$	stand. dev. of monetary policy shock
$\sigma_\tau = 0.010$	stand. dev. of fiscal transfer to banks

4 Positive Results

We used Michel Juillard's software Dynare to log-linearize and simulate our model. Figures 1 to 9 display the impulse-response functions (IRFs) of selected variables in response to shocks in the presence of equity market frictions, *i.e.* when $(\Phi_a, \Phi_z) = (0.25, 0.25)$, as well as the IRFs of the same variables to the default shock and the shock to demand for reserves in the absence of equity market frictions, *i.e.* when $(\Phi_a, \Phi_z) = (0, 0)$. The solid lines in the Figures show the IRFs under our benchmark monetary policy rule reacting to CPI inflation (Π).

In the presence of equity market frictions, the responses to familiar shocks (in Figures 1 to 3) are in accordance with conventional wisdom. Following a positive productivity shock, output, private consumption and lending rise, while inflation rates and interest rates fall. Following a restrictive monetary policy shock, output, private consumption and lending decrease together with inflation rates, while interest rates increase. A positive government-expenditures shock raises output, lending, inflation and interest rates, but decreases private consumption due to the familiar Ricardian effect.

A positive default shock (Figure 4) decreases output and hours at first. Output and hours per producing firm (y and h) rebound after two quarters, but aggregate output and hours (which have the same pattern of responses as the one we show for consumption) remain below their steady-state values for over 20 quarters. CPI inflation and interest rates rise and the volume of lending falls. Despite the decrease in output, the increase in inflation is accompanied by a small increase in the growth rate of the monetary base. Following a positive shock to the costs of securitization (Figure 5), output, hours, private consumption and lending decrease while inflation and interest rates rise. Overall, the responses in Figures 4 and 5 illustrate that default shocks and shocks to securitization costs work like adverse supply shocks in our model. A positive shock to demand for reserves (Figure 6) has the same qualitative effects as an increase in the costs of securitization. Why is an increase in the demand for reserves inflationary in our model? When banks need more reserves, their balance sheets tighten and they want to lend less. Lending rates rise and the associated cost increases the price of final goods. The higher prices curb aggregate demand and reduce consumption, output and hours. These effects, and the effect on prices of intermediate goods, however, are fairly small.[14]

To provide some intuition for the potential role of fiscal policy in our norma-

[14]Some of the small responses in our IRFs also reflect general-equilibrium interactions that we don't highlight in the text. For example, after an increase in demand for reserves, the interest rate on deposits rises (because banks try to tap the deposit market more as their balance sheets tighten) and consumers switch from buying cash goods to buying deposit goods. This reduces household demand for money.

tive analysis (later in the paper), Figure 7 shows the effects of a fiscal transfer to banks, reducing τ in (12) from its steady-state value of 0 to -0.01. This transfer increases the bank's cash flow and makes them more willing to lend. So, they cut the interest rate on loans which reduces consumer prices upon impact and stimulates spending.

The removal of the equity market frictions does not change the impulse-response functions except for shocks to the demand for reserves (Figure 9). First of all, compared to Figure 6, the contractionary effects of this liquidity shock on output, consumption and hours are an order of magnitude smaller. In Figure 6 (with the equity-market friction) the contraction reflected the increase in bank lending rates in response to tighter balance sheet conditions. In Figure 9 (without the equity-market friction), balance sheet conditions don't play a role, and lending rates actually fall (by a small amount).[15] In this case, the increase in money demand has the familiar (but small) deflationary effect.[16]

As we pointed out earlier (based on the relevant first-order conditions), banks do not engage in costly securitization if they have access to funds in a frictionless equity market. So, shocks to securitization costs play no role in this case. Also, as noted earlier, a fiscal transfer to banks has no effects– it is simply paid out as dividends. These results suggest that appropriate policy responses to liquidity shocks may depend critically on the presence or absence of frictions in the market for bank equity.

So far, we have assumed that the simple rule governing monetary policy responds to CPI inflation. Our stylized model may well overstate some related consequences. In the model, banks raise the lending rate when they are less eager to lend and retailers pass on the cost of borrowing to consumers right away (there is no rigidity in retail prices). So, the CPI inflation rate in our model is quite sensitive to financial shocks. If monetary policy responds to this

[15] This reflects a small general-equilibrium interaction. The contraction of output reduces the demand for loans, and banks compete to attract borrowers by cutting the interest rate on loans.

[16] We suspect that the small contraction in consumption reflects the wealth effect of the decrease in bank profits.

measure of inflation, then the effects of shocks on endogenous variables also reflect the resulting changes in the policy stance. The dotted lines in Figures 1 to 9 show the corresponding IRFs assuming that the simple monetary rule responds to inflation in the price index for intermediate goods (Π^X), as specified in (16). Since Π^X is less sensitive to financial shocks, these IRFs do not reflect endogenous monetary responses as much as the solid lines (the IRFs under the simple rule responding to CPI inflation) do. We will return to this point after discussing the IRFs for optimal policy in the following section.

5 Normative Results

The simple NK model has a sharp (and well known) policy implication identifying price stability as the overriding objective of good monetary policy. Does our model have the same policy prescription? One aspect of this question is about the implications of a monetary friction in most models with money demand. As Khan, King, and Wolman (2003) point out, in the context of their model with a monetary friction and price rigidity, the optimal steady-state rate of inflation has to strike a balance between two forces. First, since a positive nominal interest rate distorts the household's labor-leisure decision, optimal policy would follow the Friedman Rule– a deflationary policy keeping the nominal interest rate equal to zero– if prices were fully flexible. Second, price rigidity, by itself, would call for price stability– keeping the inflation rate equal to zero– if there were no monetary distortion (as in standard NK models). Our model has price rigidity as well as distortions from a non-zero interest rate, and optimal policy has to strike a balance between these.

We solve for the optimal (Ramsey) policy using Dynare and the program Get Ramsey developed by Levin and López-Salido (2004) and used in Levin, Onatski, Williams and Williams (2005). We find that optimal inflation is close to zero in our model. So, the normative force calling for price stability dominates the monetary frictions that call for the Friedman Rule.[17]

[17] More precisely, the optimal steady-state deflation rate is about 0.04 percent per quarter, in all versions of our model.

The second– and, for our purposes, more relevant– aspect of price stability is low volatility of inflation around the optimal steady-state value. Welfare losses in simple NK models arise from price dispersion across intermediate goods. All firms have the same marginal cost, and production efficiency would require equal outputs of all intermediate goods. To the extent that firms setting prices at different times set different prices, they will end up producing different amounts (because output is demand determined) and final-good production in (3) will not be maximized. If the policy prescription of simple NK models extends to our setting, a simple rule like (16) stabilizing Π^X should get close to optimal policy. A simple rule reacting to CPI inflation (Π) should do worse: if the central bank stabilizes Π, financial shocks cause fluctuations in bank lending rates and, therefore, in Π^X given the equilibrium condition (7) for the relative price of the intermediate-good aggregate.

5.1 Optimal (Ramsey) Monetary Policy

Figure 1 also compares the responses to productivity shocks under optimal monetary policy to the responses under our simple rules. Optimal policy allows somewhat larger increases in output and consumption and opts for a smaller decrease in inflation than our simple rule targeting CPI inflation. In particular, optimal policy essentially keeps inflation in the price index for intermediate goods unchanged. As we noted above, keeping Π^X very close to the optimal steady-state value is what we would expect to see if the central policy prescription of NK models also applies to our model. The IRFs under optimal policy and the simple rule, however, are broadly similar for the productivity shock. Comparing the IRFs in Figure 3, for a shock to government purchases, the simple rules again seem fairly close to optimal policy; but optimal policy keeps Π^X closer to zero.

The responses to a default shock, in Figure 4, show how a simple rule reacting to CPI inflation (Π) may be undesirable. Optimal policy raises output and hours per producing firm (y and h)– albeit by small amounts– while the simple rule allows these variables to fall upon impact. Although aggregate output and hours (which have the same pattern of responses as the one we show for consumption) still fall, optimal policy opts for a smaller contraction, than the simple CPI rule does, in response to a default shock. Optimal policy essentially keeps its interest rate unchanged in response to a default shock, while the simple CPI rule raises the rate to fight the inflationary effect of this adverse supply shock– and this inappropriate monetary response leads to the contractions of output and hours. The simple rule reacting to Π^X does not share this problem and its IRFs are very close to those under optimal policy.

Our finding that optimal policy does not cut the policy rate in response to a default shock may seem counter-intuitive at first. This optimal response, however, highlights the fact that a default shock by itself (i.e., setting aside any chain reactions or financial frictions that it may trigger) shares the basic features of an adverse productivity shock or a positive shock to "wasteful" government expenditures. In a social planner's solution, the optimal response to any one of these adverse shocks would involve reducing consumption and increasing the labor input. In the Ramsey equilibrium, the policy rate must adjust to bring about the optimal contraction of consumption and increase in work effort, but subject to the constraints imposed by equilibrium conditions. More specifically, comparing Figures 3 and 4, we see some similar patterns in optimal responses to an increase in government purchases and an increase in the default rate. The optimal response to either shock entails working more and consuming less. The adverse wealth effect does most of the work for reducing consumption and increasing hours, but optimal monetary policy reinforces it by raising rates slightly. The main differences between optimal responses to an increase in government purchases and an increase in the default are in how these shocks affect lending rates and the volume of lending. The first-order conditions of banks require the lending rate to rise sharply, making the volume of loans fall, in response to a default shock.

Following a shock that hampers securitization, optimal policy (Figure 5) allows output, consumption, labor hours, and lending to fall. To bring about the decrease in the volume of loans as an equilibrium outcome, lending rates must rise; and this increases CPI inflation. The inflation, in turn, is accompanied by an expansion of the monetary base, which prevents a sharp drop in real money balances. The simple CPI rule in Figure 5 leads to qualitatively similar responses. Optimal policy, however, entails a very small (12 basis points per annum) increase in the policy rate (immediately followed by a small interest-rate cut), while the simple CPI rule raises the policy rate substantially to fight CPI inflation. Consequently, the contractions in output, consumption, and hours are smaller under optimal policy than they are under the simple rule. Again, the problem with the CPI rule is that it reacts to the effect of higher lending rates on inflation, and the simple rule reacting to Π^X does not share this problem.

A positive shock to demand for reserves (in Figure 6) has essentially the same qualitative effects as a securitization shock (in Figure 5). The only qualitative differences are in the responses of inflation in the price of intermediate goods and the policy rate– optimal policy cuts the rate when the liquidity shock arises from stronger demand for reserves. The magnitudes of these responses, however, are very small for both shocks.

In quantitative terms, the optimal contractions in output, consumption, and hours are about half as large in Figure 6 (when a liquidity shock arises from an increase in demand for reserves), compared to Figure 5 (when the shock originates from securitization problems).[18] As we explained in Section 3, we have set the standard deviations of these two shocks such that they have the same impact effect in terms of tightening the banks' balance sheets (i.e., making banks choose between cutting loans and cutting dividends). So why does optimal policy have to tolerate a larger contraction when the shock originates from securitization problems?

The answer, we suspect, has to do with the fact that a problem in securities markets is a real problem; monetary policy does not have a direct policy instrument to address it in our model (although, in reality the FED has been very innovative in devising new and unconventional policy instruments in re-

[18]These differences are hard to see on the scale of our Figures, but the impact effect on output is -0.09 percent in Figure 5 versus -0.04 percent in Figure 6.

sponse to problems in securities markets). The securitization shock tightens bank balance sheets, but printing money is not an effective way to deal with a liquidity shock that does not directly increase money demand. Nominal money growth only increases by 0.1 percent in Figure 5. By contrast, when the gist of a liquidity shock is that banks want more money, monetary policy has a direct instrument. Nominal money growth increases to over 3 percent per quarter– 30 times the optimal response to the securitization shock– when a liquidity crunch arises from stronger demand for reserves. Optimal policy in our model is quite generous in accommodating the demand for bank reserves, and does not cut the policy rate much.

In Figure 6, compared to optimal policy, our simple rule responding to CPI inflation tolerates much larger contractions in output, consumption, and hours, when the demand for reserves increases. The difference arises from the fact that the simple rule raises the policy rate to fight inflation, while optimal policy cuts the policy rate to moderate the contraction. Once again, the simple rule reacting to Π^X comes closer to optimal policy.

Optimal responses to an increase in demand for reserves in the frictionless model (Figure 9) are quite different from optimal responses when there is an equity-market friction (Figure 6).[19] With no friction, optimal policy can actually make banks cut their lending rate and lend more. This leads to (small) expansions of output, consumption and hours. Absent the friction in the market for bank equity, an increase in demand for reserves does not pose a serious problem for monetary policy because the lending and funding sides of banks are essentially decoupled.

5.2 Welfare Losses

Our welfare criterion is the utility function of the representative household. We compute the conditional expectation of the household's value function starting in the deterministic steady state and express welfare differences as consumption

[19]While they are quite similar for non-financial –not reported here– as well as for default shocks, see Figure 8 relative to Figure 4.

equivalents following Lucas (2003).[20] Given an equilibrium E_1(say, under Policy 1) and a better equilibrium E_2 (under Policy 2), we calculate the percentage increase in consumption in E_1that would compensate consumers for living under Policy 1 instead of Policy 2. For example, a welfare loss of 0.1 percent means consumers are indifferent between having Policy 2 and a scheme that operates Policy 1 but somehow augments their consumption by 0.1 percent each period. The mechanical details of how we calculate conditional welfare and express differences in consumption units are as described in Canzoneri, Cumby, and Diba (2007).

We calculate the welfare losses from simple rules relative to optimal policy. In general, the computed welfare losses are quite small. For instance, the rule involving a response to inflation in the price index for intermediate goods only entails a welfare loss of 0.03 percent compared to optimal policy.[21] That is, augmenting consumption by 0.03 percent each period would be enough to compensate consumers for living under the simple rule, instead of having the fully optimal policy in effect. In this sense, the normative punch line of simple NK models applies to our model: a simple rule that stabilizes the "right" measure of inflation is optimal, or very close to optimal.[22]

Do these welfare results imply that the conduct of monetary policy doesn't matter much in our model (as it is often the case in the NK model)? One way to answer this question is to consider the performance of alternative monetary policy procedures that have been or are being used in the real world. For instance, consider a rule that sets an almost constant growth rate for the money supply.[23] The welfare cost of this policy is 1.26 percent in our model. This is not

[20]The results are much the same if we use the unconditional expectation instead.

[21]Somewhat larger but also quite small is the welfare loss associated with a rule involving a response to CPI inflation.

[22]To be clear, we think one could introduce shocks (like a shock to monopoly markups) that are likely to create policy tradeoffs and break the policy prescription of targeting the appropriate inflation rate in our model (because we know how to create policy tradeoffs in NK models without banks). The point is that the shocks and frictions we have introduced do not break this normative prescription of NK models.

[23]More precisely, we set nominal money growth equal to 1.15 times the steady-state inflation rate minus 0.15 times last-quarter's inflation rate. We need this negative response to lagged inflation to get determinacy in our model.

surprising: as we saw above, optimal policy allows money growth to fluctuate considerably in response to shocks to the demand for reserves in our model.

As a second example consider an interest-rate rule that responds to the deviation of output from its *steady-state* value: policy turns expansionary (contractionary) when output is below (above) trend– or the steady-state value in our model abstracting from growth. We consider a simple rule with the same values for the inertia parameter (0.8) and the response to CPI inflation (1.5) plus a response to the "output gap" with a coefficient of 0.5 (and we define the gap as the percentage deviation of output from its steady-state value).[24] While it is well known in the literature that this rule does not have good properties (see Rotemberg and Woodford, 1997, Cúrdia and Woodford 2009b,c) the welfare cost of using such a policy is quite substantial in our model (0.58 percent).

Our welfare costs under "bad" policies are an order of magnitude (or more) larger than Lucas's (2003) estimates of potential welfare gains from "further improvements in short-run demand management." As such, avoiding mistakes in the conduct of monetary policy does matter according to our model.

5.3 Optimal Fiscal and Monetary Policy

Is there scope for fiscal intervention in response to financial shocks? If so, how would the presence of optimal fiscal policy change the optimal monetary responses to shocks? Answering these questions, of course, would require modelling both the benefits of fiscal intervention and the costs arising from tax distortions. We think our model is a useful framework for organizing our thoughts about the benefits of fiscal intervention: if the gist of the problem is that financial shocks tighten the balance-sheet condition of banks, a fiscal transfer can serve to loosen the constraint. A convincing treatment of the costs of fiscal intervention, however, would take us too far afield– and we don't pursue it in this paper.[25] So, our discussion below only highlights the scope for fiscal intervention

[24]The coefficient of 0.5 on the gap comes from a common rendition of the "Taylor Rule," but theoretical evaluations [surveyed in Taylor and Williams (2009)] usually assume that the central bank can observe the output gap based on the model's natural level of output.

[25]We suspect that having distortionary taxes instead would affect the size of the fiscal intervention but not its qualitative properties.

when a perfect policy instrument– a transfer financed by a non-distortionary tax on households– is available.

Once we compute jointly optimal fiscal and monetary policies, the policy response to a securitization shock is purely fiscal, and this fiscal response exactly offsets the effects of the shock. This finding is intuitive in the context of our stylized model with a lump-sum tax: a fiscal transfer from households to banks can save households the resource cost of the securitization shock. Since fiscal policy perfectly neutralizes the effects of the shock, there is no reason for monetary policy to respond.

Optimal fiscal policy also makes a transfer to banks when the demand for reserves increases. This shock, however, calls for a monetary response as well. In Figure 10, this monetary response and the responses of other variables virtually coincide with the ones under optimal monetary policy in the absence of a friction in the equity market. For example, under jointly optimal policies there is a small increase in output, as is the case under optimal monetary policy in the frictionless model. By contrast, lacking the fiscal instrument, optimal monetary policy has to tolerate a decrease in output when there is a friction in the equity market. These findings are also intuitive. The fiscal instrument is essentially used to offset the friction in the equity market, and optimal monetary policy opts for essentially the same solution that it would choose in the absence of this friction.

As we noted earlier, optimal responses to a default shock are much the same with or without the friction in the market for bank equity. This is because this friction only matters for whether or not shocks to the funding side are transmitted to the lending side, while a default shock directly affects the lending side of banks. For this shock, the IRFs under optimal fiscal and monetary policy (not displayed) virtually coincide with the IRFs under optimal monetary policy (in Figures 4 and 8).

Interestingly, the Fed assumed a less conventional and more fiscal role during the recent financial crisis. Our model is suggestive about the scope for unconventional monetary policy but fails to capture any costs. As it stands, our model would imply that the central bank should take over financial intermediation altogether and save the costs of all the distortions that arise from our imperfect banking sector! Absent a convincing way to model and quantify the costs of unconventional monetary policy, it seems difficult to assess the scope for these interventions.

6 Extensions

In our model, the positive and normative implications of liquidity shocks (shocks that hamper securitization or increase the demand for bank reserves) depend critically on the presence of frictions in the market for bank equity. Absent such frictions, the lending and borrowing sides of our banks are essentially decoupled; and liquidity shocks do not affect the lending side much. When we add a friction, modelled as a dividend smoothing motive, liquidity shocks have important effects on lending rates and call for a policy response.

The way we model dividend smoothing is ad hoc. The models developed by Gertler and Karadi (2009) and Gertler and Kiyotaki (2009) also involve assumptions that serve the same purpose as our ad-hoc rendition.[26] Since the presence or absence of a friction in the market for bank equity has important implications, a better structural understanding of it seems essential for assessing its potential importance in reality. This is particularly important in the context of jointly optimal monetary-fiscal policy. Under our specification, the optimal policy response to a securitization shock is purely fiscal; monetary policy does not respond, but fiscal policy uses transfers (tax cuts) to reverse the tightening of bank balance sheets. In response to an increase in the demand for reserves, the fiscal instrument is essentially used to offset the friction in the equity market, and optimal monetary policy opts for essentially the same solution that it would choose in the absence of this friction. It remains to be seen whether and to what extent optimal fiscal policy would still aim at (and accomplish efficiently) bank

[26]In these models, banks only pay dividends when they are randomly hit by an exit shock (which hits the same number of banks each period). Exiting banks are replaced by new, but under-capitalized, banks.

recapitalization if features such as adverse selection, moral hazard, and tax distortions were present.

To our knowledge, the corporate finance literature notes the prevalence of dividend smoothing but does not go beyond our ad hoc rendition. We are not aware of any model of the agency problem between managers and share holders that leads to dividend smoothing.[27] In the context of banks, however, we think a better structural understanding of funding frictions, and the role of securitization, may involve modelling capital-adequacy constraints. In reality, banks have a low marginal cost for the funds they raise in deposit and interbank markets. Equity finance is more costly, and a binding capital-adequacy constraint may well pin down the composition of bank liabilities and net worth. Pinning down this composition—i.e., breaking the Modigliani-Miller theorem—is essentially what the ad hoc dividend-smoothing motive accomplishes in our model. We think incorporating a capital-adequacy constraint and taking note of how it is affected by securitization is a promising direction for future work.

Our model presumes smoothly functioning– albeit less than perfect– financial markets. As such, our focus is on optimal policy during normal times; we don't address some important concerns (like contagion in default risk or the collapse of markets under asymmetric information) that policymakers may have had during the recent crisis. We also assume that default is exogenous and that it can be predicted before the loans are made (as in Cúrdia and Woodford (2009a, c)). Since there are no default decisions or information asymmetries in our model, there is no credit rationing. For the same reasons, banks do not need to impose a collateral constraint on borrowers. But in spite of all these limitations we still feel that understanding optimal policy in our model setting is a useful exercise in its own right, and could also serve as a starting point in organizing our thoughts about the recent financial crisis.

One question that has received attention in the literature is whether or not

[27] Our presumption is that simple models with symmetric information cannot capture the relevant agency problem between managers and shareholders. In reality, managers may be better informed, than shareholders are, about the quality of assets and may use dividend policy as a way to signal financial strength, or hide weakness.

adverse financial shocks put the central bank at risk of hitting the zero-bound on nominal interest rates. The answer, within the confines of our model, is "not under optimal policy or simple inflation targeting rules." As we have already noted, positive default shocks are akin to adverse supply shocks in our model; they generate (small) interest rate hikes under optimal policy (and larger hikes under CPI targeting). And in response to an increase in the demand for liquidity, optimal policy essentially keeps its interest rate constant– allowing the money supply to expand endogenously. Since neither optimal policy nor our simple rules call for a significant decrease in the policy rate, adverse financial shocks (by themselves) do not create a risk of hitting the zero bound.

By contrast, in Cúrdia and Woodford's model, a shock that works like our default shock does lead to a decrease in the policy rate under optimal policy and may be deflationary under some simple rules (but not under optimal policy). We suspect that these differences may arise from the fact that in Cúrdia and Woodford's model borrowers are households, and a default shock that increases bank lending rates curbs aggregate demand. In our model, borrowers are firms; financial shocks that increase bank lending rates affect the supply side. Adverse financial shocks are effectively adverse supply shocks and lead to a contraction of output as well as a rise in inflation.

During the recent financial crisis, however, banks mostly responded to adverse financial shocks by reducing the volume of loans and inflationary pressures were not an immediate concern (nor were any strong deflationary pressures apparent). An extension of our model to a setting with asymmetric information and credit rationing may be of interest. In such a setting, the volume of credit may replace our bank lending rates as an indicator of financial stress, and inflation may play a less important role as a barometer of macroeconomic conditions.

7 Conclusions

In this paper we have added banks and also included frictions in the market for bank capital to the standard New Keynesian model. We have used this model to study the positive and normative implications of financial shocks. Several novel results emerge from the analysis.

First, the existence of the equity market friction matters significantly for the effects of the shocks and the properties of optimal monetary policy. An interesting finding is that for shocks that increase banks' demand for liquidity, optimal monetary policy accepts an output contraction. This would not have been the case in the absence of the friction. Hence, monetary policy becomes less accommodating to liquidity shocks under equity market frictions.

Second, optimal policy involves large adjustments in the money supply, a property reminiscent of Poole's analysis. Consequently, restrictions on the quantity of money supplied by the central bank can carry significant welfare costs in times of financial turbulence.

And third, the presence of financial frictions and financial shocks do not invalidate the well known implication of the standard NK model that a simple interest-rate rule that targets inflation is close to the optimal policy.

The main weakness of the present analysis lies in its specification of the bank equity market friction. Extensions that would model such a friction in a more compelling fashion appear to us to be of high value added from both a positive and normative point of view, specially regarding the joint properties of optimal fiscal and monetary policy.

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Figure 1: Responses to productivity shock

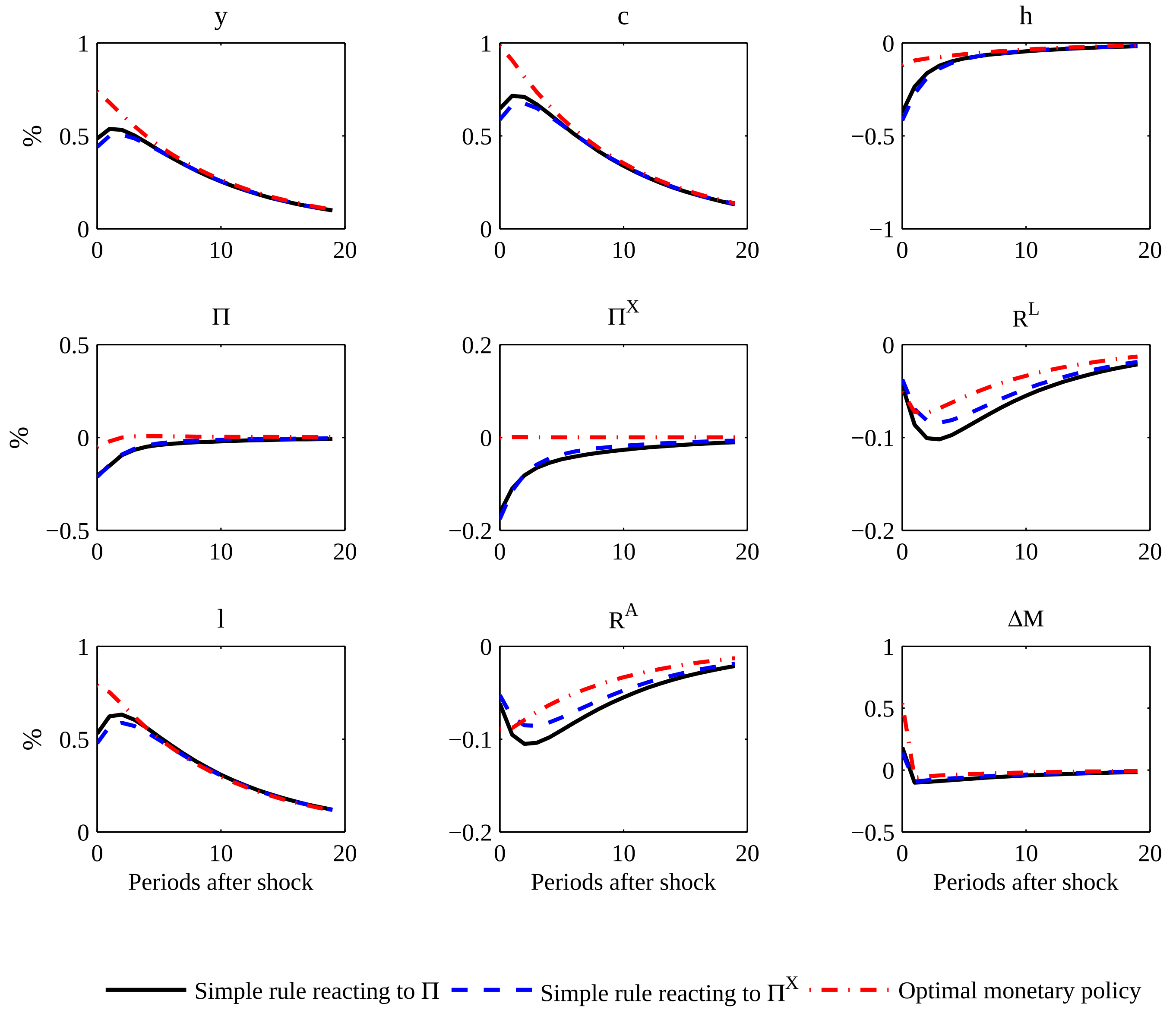


Figure 2: Responses to monetary policy shock

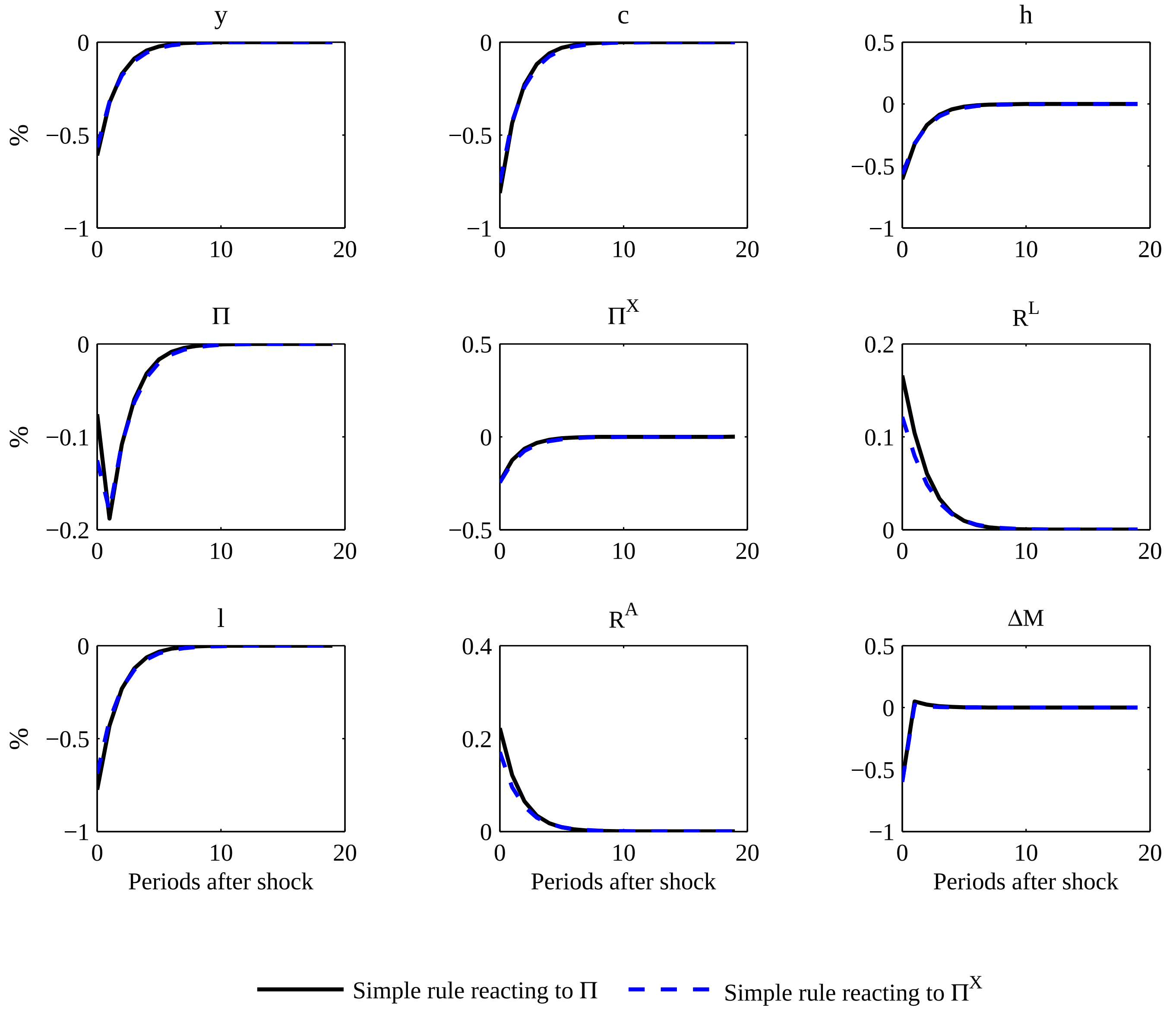


Figure 3: Responses to government-expenditures shock

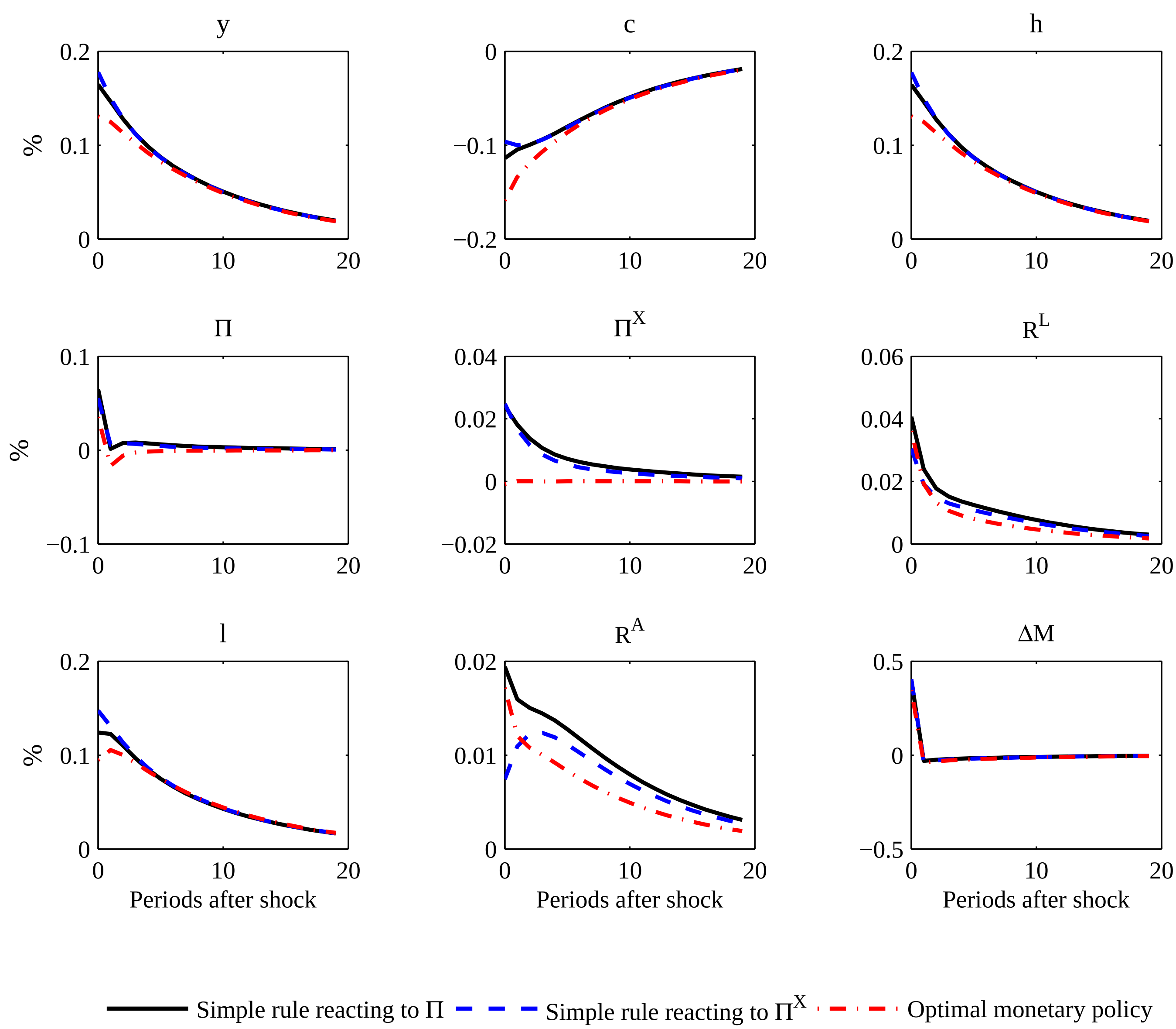


Figure 4: Responses to default shock

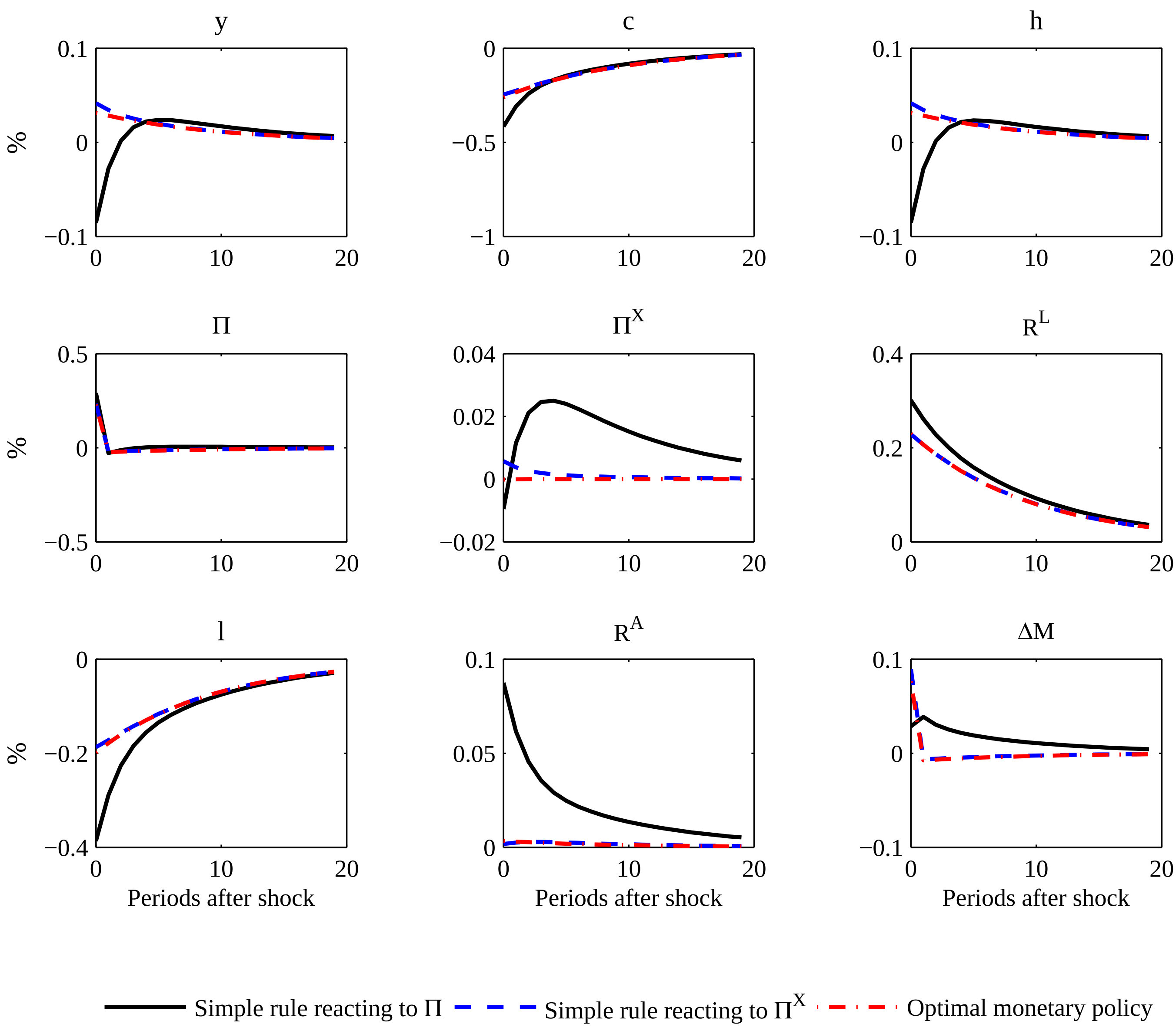


Figure 5: Responses to securitization shock

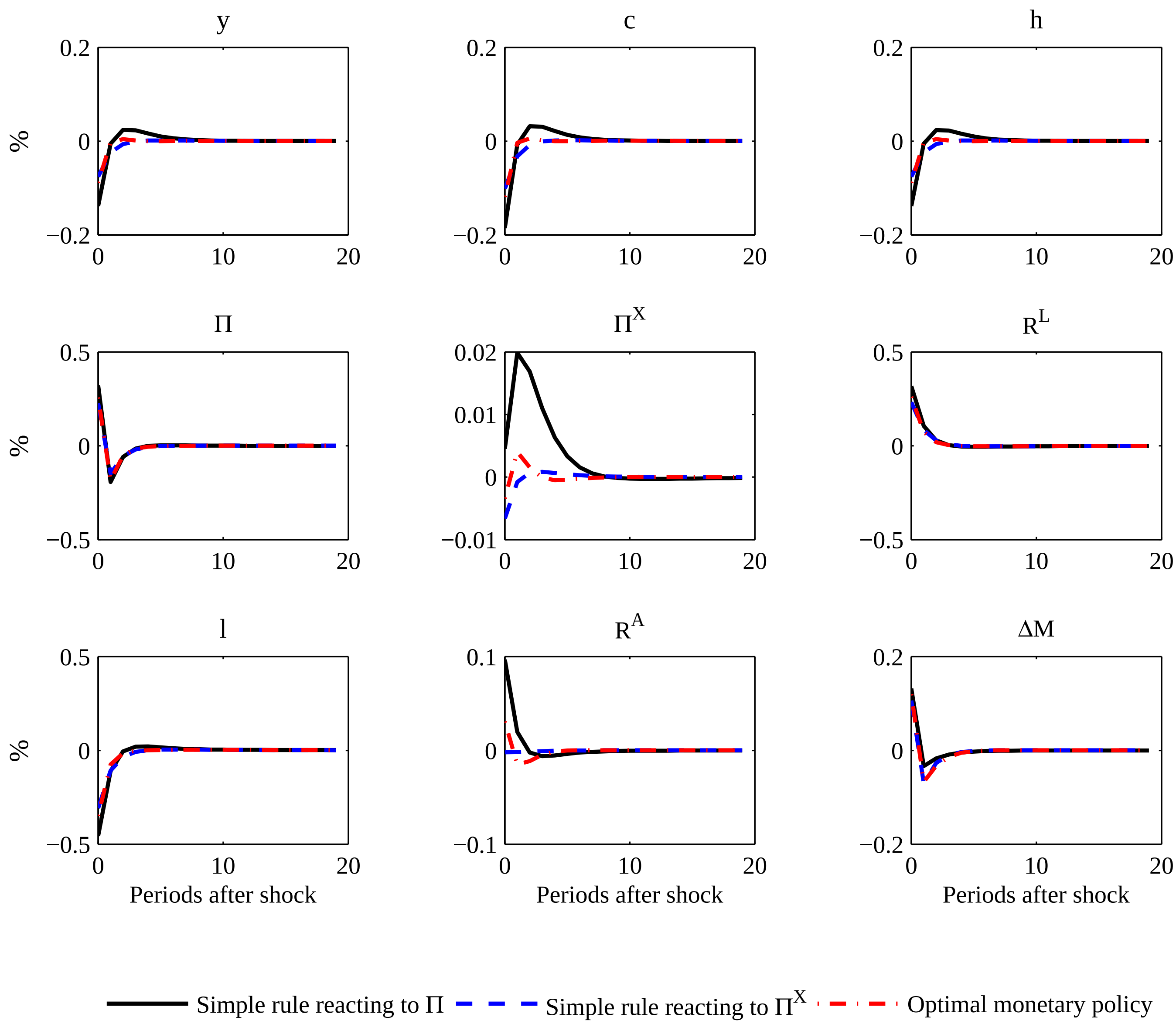


Figure 6: Responses to shock to demand for reserves

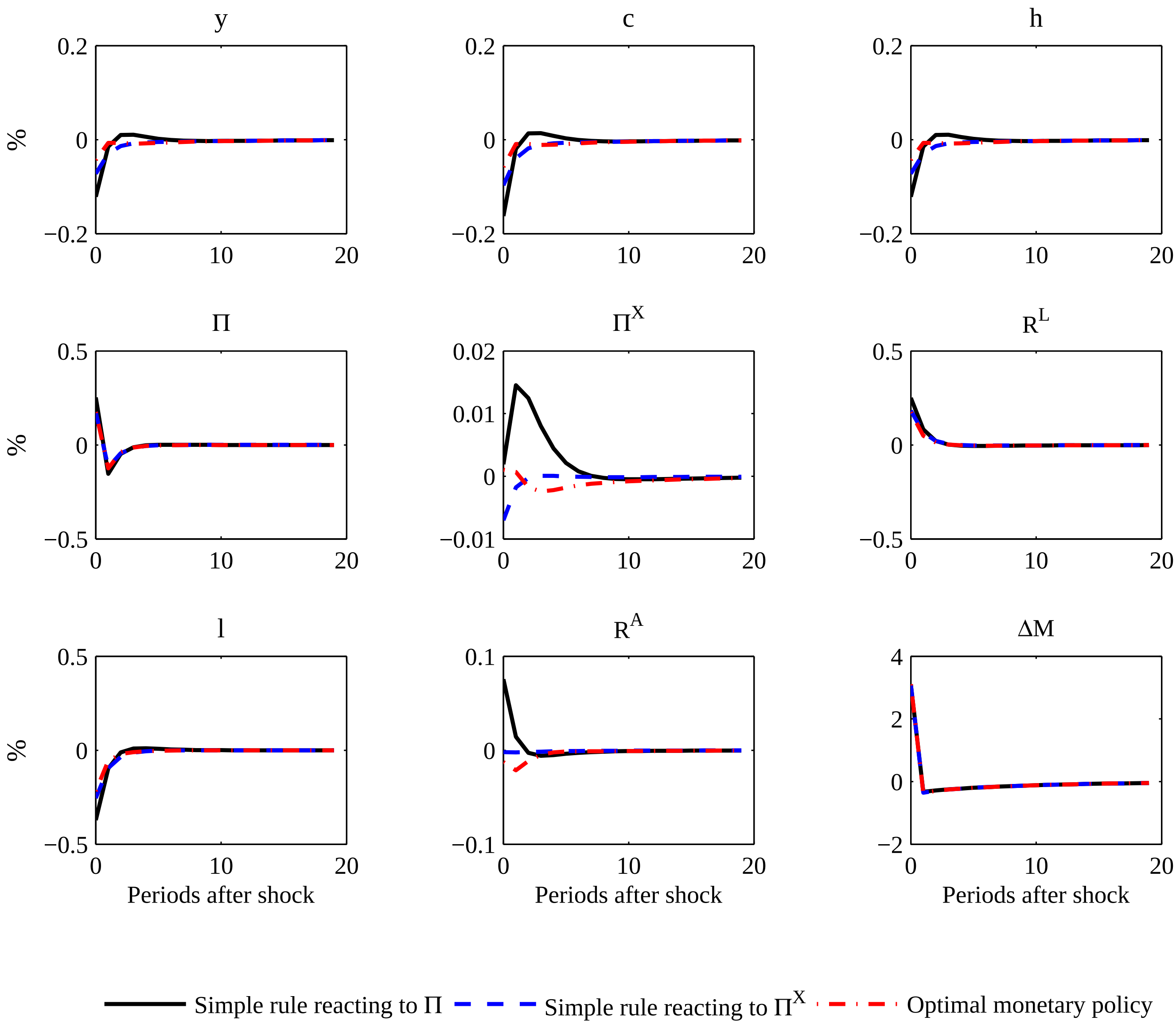


Figure 7: Responses to fiscal transfer to banks

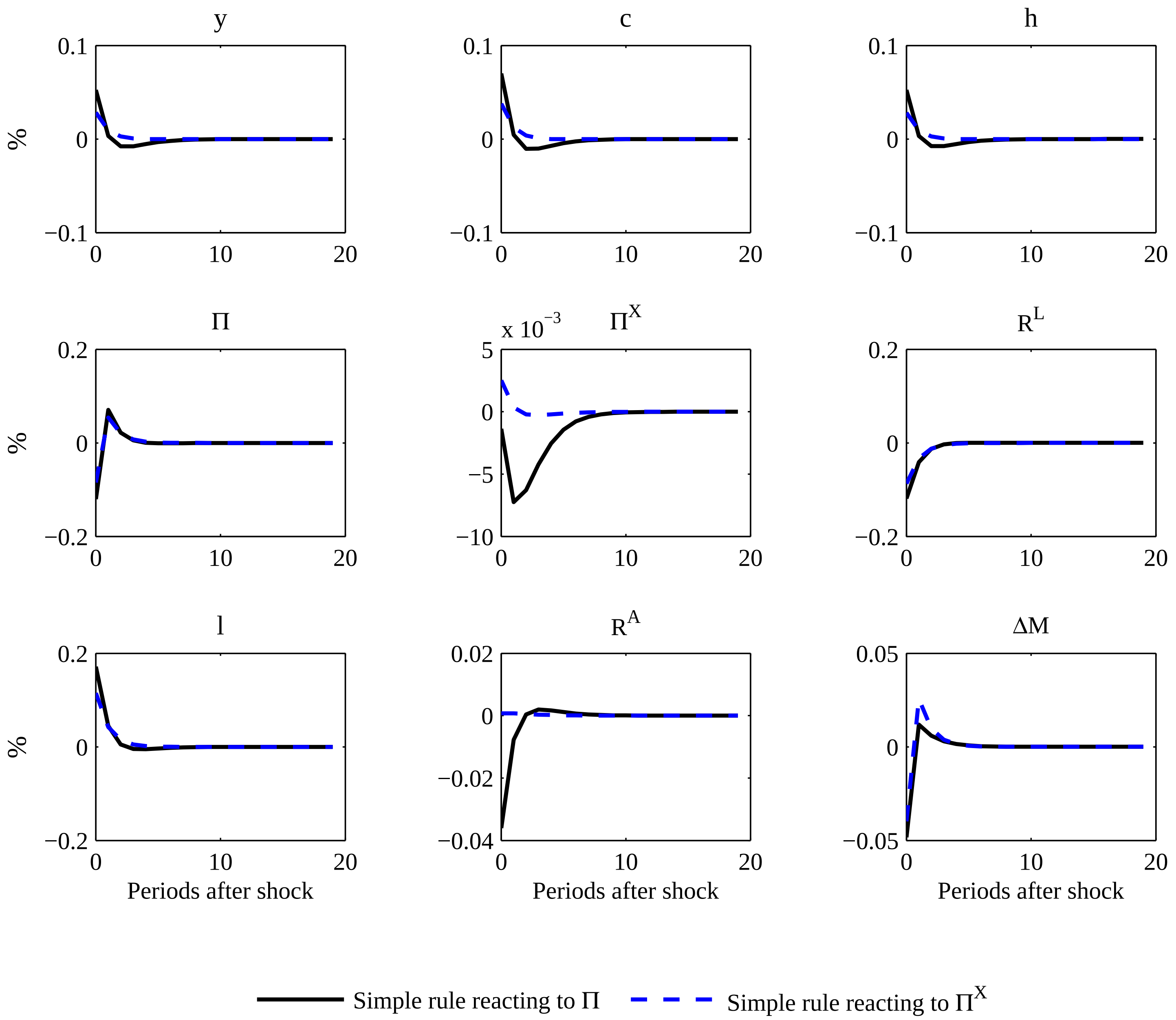


Figure 8: Responses to default shock in the absence of equity market frictions

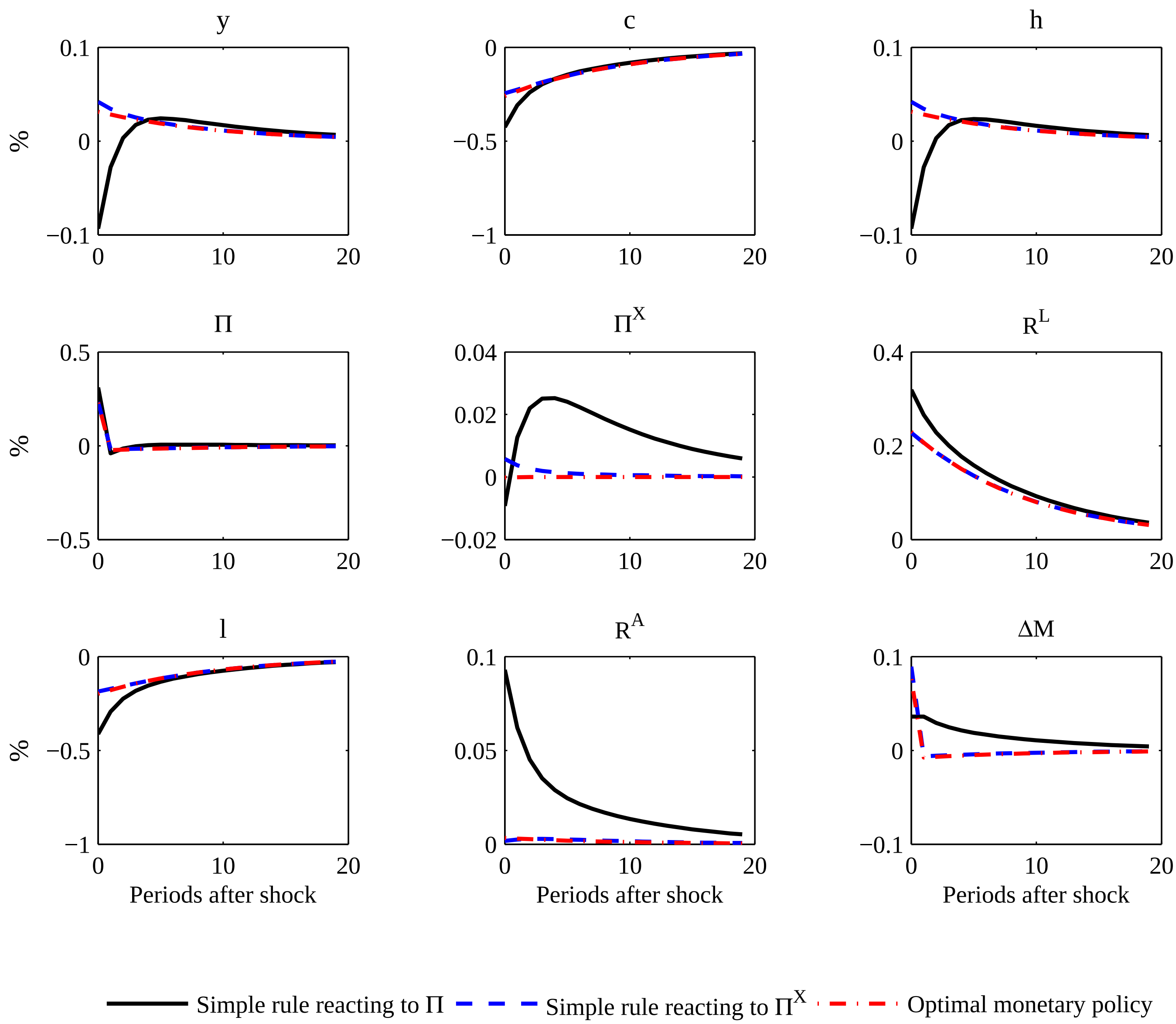


Figure 9: Responses to shock to demand for reserves in the absence of equity market frictions

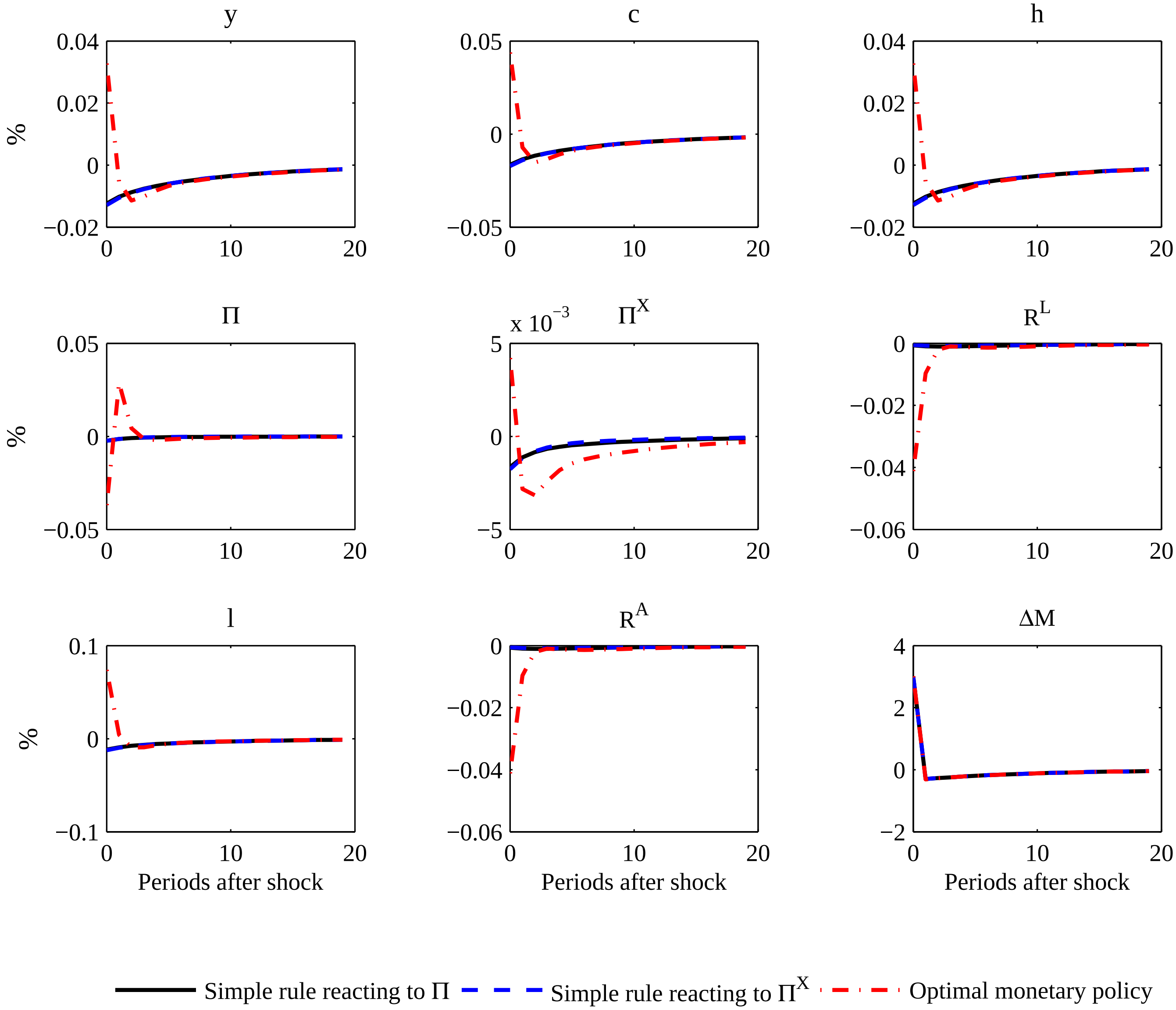
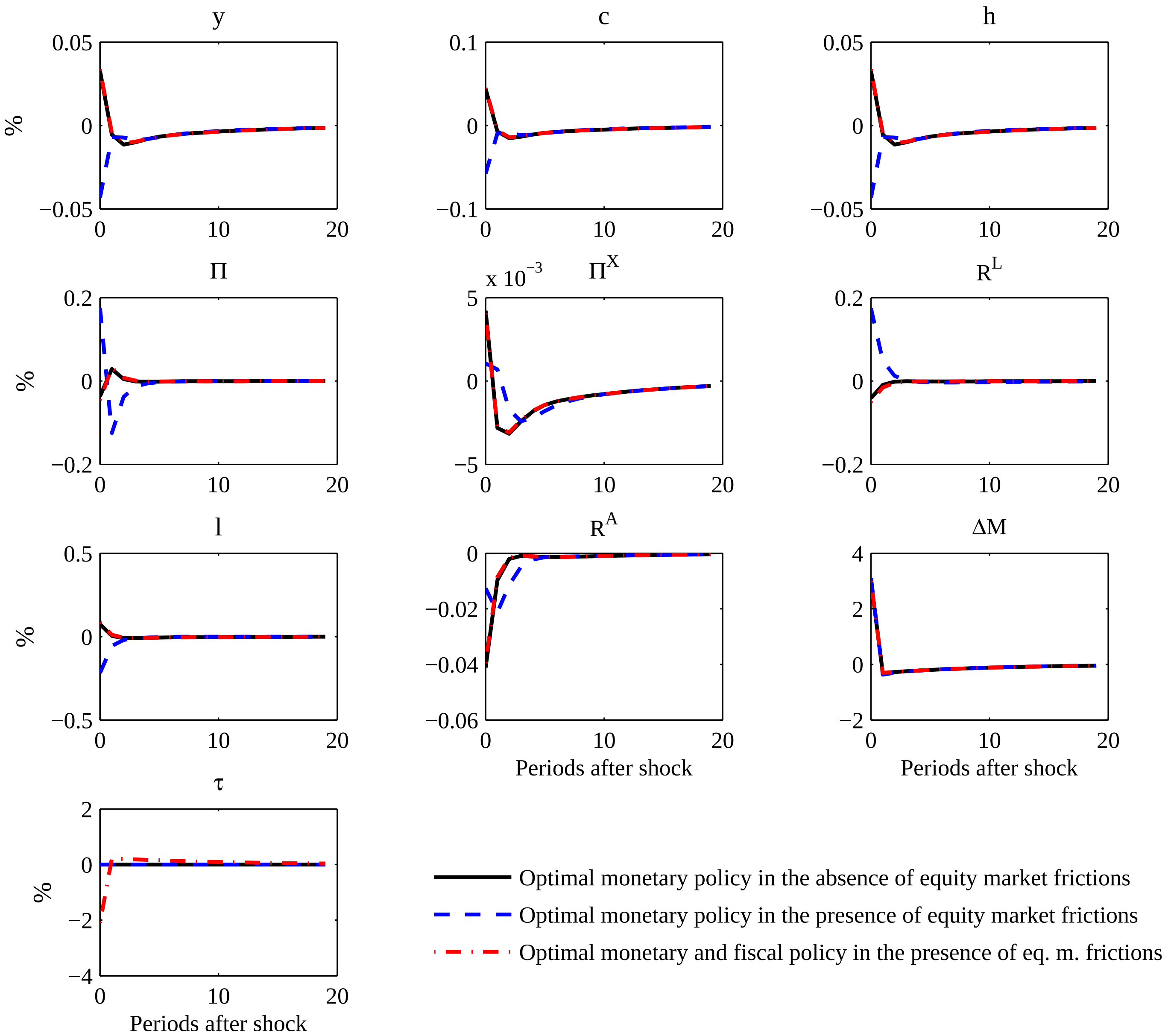


Figure 10: Responses to shock to demand for reserves



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