Monopolistically Competitive Financial Intermediaries in a DSGE Model

Jochen H. F. Güntner♦

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Abstract

This paper crucially builds on the reconsideration of banking and interest rates in monetary policy analysis by Goodfriend and McCallum (2007), extending their model in two directions. On the one hand, it includes an endogenous cost of deposit provision subject to an exogenous inside money premium shock. On the other hand, the products of two financial intermediaries are imperfectly substitutable against each other. Commercial banks can thus take advantage of a certain interest rate-setting power, yet, being restrained in their decision by positive interest rate adjustment costs. The model is reasonably well able to explain the source of endogenous interest rate differentials, and how these spreads depend on the values of parameters inherent to the banking system. Under the chosen benchmark calibration, it predicts an inside money premium on sight deposits of 2% p.a., and an external finance premium on loans of 2.2% p.a.. The dynamic analysis attests bank related shocks a minor role in the business cycle. Besides, limited competition in the market for deposits seems to act as a financial accelerator, while an equivalent market structure among lenders cushions the impact of restrictive monetary policy.

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♦ Corresponding author. Chair of Economics II - Economic Theory, Otto-von-Guericke-University Magdeburg
E-mail address: jochen.guentner@ovgu.de
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1. Introduction

The past decade has given birth to an enormous amount of academic work trying to reproduce the qualitative and quantitative features of real business cycles and to evaluate the potential of monetary policy to steer economic activity. Entirely aware of Lucas' critique that any model destined to predict the effects of a policy experiment must be structural, i.e. rely on the "deep" parameters only which relate to preferences, technology, and resource constraints, economists have agreed upon what Goodfriend and King (1997) call *The New Neoclassical Synthesis*.

Accordingly, recent theoretical research has generally taken the approach of micro-founded macroeconomic models based on intertemporally optimising private agents, whose decisions are subjected to budget and further constraints, and influenced by various types of exogenous disturbances. Highly elaborate examples of these state-of-the-art DSGE models are discussed in Woodford (2003) and Smets and Wouters (2003, 2005, 2007), to name only a few.

However, what remains indeed a reason for unease, as Goodfriend and McCallum (2007) put it, is the common feature that most of the models are fundamentally non-monetary. In view of the recent developments in global financial markets and their spill over to the real economy, a standard framework without any role for monetary aggregates, explicit modelling of financial intermediaries, or endogenous interest rate differentials seems increasingly incomplete. Those important opponent contributions, for instance by Woodford (2003) in his celebrated volume *Interest and Prices*, Woodford (2007), or by Ireland (2004), which suggest that money plays a minimal role in the business cycle at best, neither incorporated any kind of incompleteness of credit markets nor a distinction between different short-term interest rates.

Consequently, the present paper follows prior approaches to implement a banking sector in an otherwise standard New-Keynesian DSGE model with nominal and real rigidities. It is thus an attempt to continue a line of work including Bernanke and Gertler (1989, 1995), Christiano and Eichenbaum (1995), Carlstrom and Fuerst (1997), Bernanke et al. (1999), Ireland (2003), Goodfriend (2005), and more recently Goodfriend and McCallum (2007), Stracca (2007), as well as Gerali et al. (2008). While all these studies set out to shed light on "the black box" of the credit channel, Ireland (2003) was the first in the above row to include a demand for money that facilitates transactions. Goodfriend (2005) pursues the distinction between narrow money, made up of currency and bank reserves, that accommodates automatically whenever monetary policy targets the interest rate, and broad money, including bank deposits and highly liquid assets, which, according to the author, must not be ignored in a model destined to serve as a guide to monetary policy. The approach is rendered dynamical to permit an assessment of the quantitative effects of financial intermediation in the subsequent paper by Goodfriend and

McCallum (2007). In a framework where the production of credit contracts requires collateral as well as monitoring effort, the *EFP* becomes endogenous. At the same time, bank deposits, i.e. broad money, is a prerequisite for transactions. Accordingly, the authors identify two opposing effects of an explicitly modelled banking sector: On the one hand the well-known "financial accelerator", resulting from a decrease in the value of borrowers' collateral under adverse economic conditions, which tends to increase the need for monitoring and the *EFP*, intensifying the impact of the initial disturbance. On the other hand a "banking attenuator" which arises from the tendency of consumption to fall during an economic slowdown, thereby lowering the demand for bank deposits and redirecting part of the borrowers' net worth into collateral-eligible assets, which potentially reduces the *EFP* in their framework.

Similar to the latter, our model evolves around a two sector economy containing intermediate goods producing firms as well as financial intermediaries. Goods producers hire labour and accumulate capital to manufacture a diversified output good that is sold in a monopolistically competitive market. As working costs are due at the beginning of period, while returns accrue at the end, firms rely on one-period bank loans to finance the wage bill and their investment expenditure. Costly monitoring effort induces banks to demand an *external finance premium (EFP)* on top of the risk-free reference rate, while the borrower's collateral, composed of a firm's expected earnings and productive capital stock, substitutes for monitoring as an input to the loan production function. In addition to credit contracts, banks provide a second type of financial intermediation, storing funds of private households in form of sight deposits. Due to costly administration, the return paid on deposits is below that of a risk-free asset. They are demanded by households, nevertheless, providing liquidity services that are necessary for a fluctuating share of consumer purchases. Accordingly, this interest rate differential will be referred to as an *inside money (IMP)* or *liquidity premium*. Neither credit nor deposit contracts are perfectly substitutable against each other, i.e. we assume a monopolistically competitive market pattern in the banking sector, too. Financial intermediaries can thus expand the spread between the risk-free reference rate and the loan or deposit interest rate, respectively, by more than the *EFP* or *IMP*.

Due to the fact that intermediate goods producers accumulate only productive capital, whose real price is fixed to unity in our model, and borrow against this capital stock as well as end-of-period profits, the "financial accelerator" in the sense of Bernanke et al. (1996) is mainly switched off. Still, the value of collateral, the demand for monitoring effort, and the external finance premium remain subject to changes in a firm's stock of physical capital and expected profit; two generally pro-cyclical quantities likely to amplify impulse responses. In any case, this paper focuses on the particularities of a monopolistically competitive banking sector with endogenous costs of deposit and loan provision. By permitting financial intermediaries to set the respective interest rates liable to quadratic adjustment costs along with Rotemberg (1982), we thus add a new channel to the possible transmissions of monetary policy and other shocks.

A lagged or incomplete response of bank rates to changes in the policy interest rate can be expected to cushion the impact of nominal and real disturbances. We will therefore refer to it as the "financial attenuator" below, though it has a different origin than the banking attenuator in Goodfriend and McCallum (2007).

The rest of the paper is organised as follows. Section 2 introduces the main actions and timing as well as the agents of our model economy. Section 3 derives their intertemporally optimal behaviour. Section 4 contains the system of equations in symmetric equilibrium. The model's parameters are calibrated and steady-state results are presented in section 5. In section 6, we analyse the reactions of selected variables to the 5 different shocks, and perform a sensitivity analysis of the impulse responses to a contractionary monetary policy shock with respect to several parameters characterising financial intermediation. Finally, section 7 concludes.

2. The Model

2.1 Non-technical Overview and Timing

Our economic environment contains 6 types of agents: A representative private household, a representative finished goods-producing firm, a continuum of intermediate goods-producing firms, a continuum of financial intermediaries, and an independent monetary authority. Time is indexed by $t = 0,1,2,...$.

At the beginning of every period, intermediate goods producers take out a loan from one of the financial intermediaries to finance labour input in current production and investment into new capital that will be productive as of period $t+1$. Banks "produce" these loans combing two substitutable input factors, namely labour to screen and monitor borrowers and collateral. Since only monitoring is costly, more collateral reduces the cost of providing a loan and thus its price, i.e. the credit interest rate demanded by the financial intermediary. The borrowed funds enable firms to hire labour and produce a diversified intermediate good that they sell in a monopolistically competitive market. The representative final goods producer assembles the continuum of intermediate goods to an output good that can be invested by firms or consumed by private households. The market for the final good is perfectly competitive. A central bank performs monetary policy according to a simple Taylor rule. It provides commercial banks with high-powered money in exchange for risk-free bank bonds, which yield a return equal to the policy rate. The representative household supplies labour to firms and banks, earning an identical wage rate in both sectors. Due to asymmetric information in the consumer market, final goods producers demand an evidence of solvency, i.e. households must support a certain share of their planned consumption expenditure through bank deposits. While the latter yields a positive return, it falls short of the risk-free rate by the bank's cost of providing liquidity. Imperfectly competitive intermediate goods producers and extract monopolistic profits which are distributed to the owner, the representative household, as deposits at the end of period. Similarly, the central bank transfers its proceeds from seignorage to private households. These resources are finally spent on consumption or invested into sight deposits to provide liquidity services and to save for future periods.

2.2 The Representative Household

The infinitely-lived representative household derives utility from real consumption of the final good c_t and from the consumption of leisure time. Its aim is to maximise discounted lifetime utility

$$E_t \sum\nolimits_{v=0}^{\infty} \beta^v U_{t+v} , \qquad \text{where} \qquad U_t = \ln c_t - \phi(n_t + s_t) .$$

In the above function, β represents the private discount factor; a measure of time preference. n_t and s_t are the shares of total time endowment (normalised to 1) the household dedicates to labour in the intermediate goods-producing firm and the financial intermediary, respectively. Accordingly, $1-n_t-s_t$ measures the household's consumption of leisure, while its $\ln$ can be approximated by $-(n_t+s_t)$.

Due to asymmetric information about the agent's solvency, a varying share of consumption must be secured by bank deposits d_t. This additional restriction is implemented by means of a standard DIA constraint. Private consumption is financed out of labour income and dividends, paid either by the intermediate goods-producing firms or the financial intermediaries, out of seignorage proceeds transferred by the central bank, or private savings which take the form of sight deposits at the financial intermediaries or financial investment into a risk-free bond b. Maximisation is thus subjected to the budget constraint,

$$c_t + b_t + d_t + \frac{\phi_d}{2}\left(\frac{d_t}{d_{t-1}} - 1\right)^2 d_{t-1} \le w_t(n_t + s_t) + \frac{d_{t-1}R_{t-1}^d}{\pi_t} + \frac{b_{t-1}R_{t-1}}{\pi_t} + g_t + g_t^f + g_t^{cb} ,$$

on the one hand, and to the Deposit-in-Advance constraint, $\alpha_t c_t \le d_t$, on the other hand. In addition to consumption expenditure, household income is spent on new financial investment, either in the risk-free bond or bank deposits, and on the costly adjustment of deposit holdings. The DIA constraint embeds a mean reverting AR(1) shock, $\alpha_t = \rho_\alpha \alpha_{t-1} + (1-\rho_\alpha)\alpha + \varepsilon_t^\alpha$, that sways around a long-run share of consumption α to be guaranteed by the household's credit worthiness. d_t can, therefore, be thought of as an aggregate including both sight deposits and cash. ε_t^α represents a Gaussian white noise disturbance. Apart from their necessity for part of consumption purchases, funds deposited with a financial intermediary yield a positive gross return R^d, while any change in the amount of d gives rise to quadratic adjustment costs. The representative household determines his lifetime-utility maximising levels of $\{c_t, n_t, b_t, d_t\}$ subject to the above constraints.

2.3 Monopolistically Competitive Intermediate Goods-Producing Firms

The continuum of intermediate goods producers is indexed to the interval $i = [0,1]$. Hiring (homogeneous) labour $n_t(i)$ from the representative household, firm i produces a slightly differentiated intermediate good $y_t(i)$ according to a constant returns to scale technology. By selling their output in an imperfectly competitive market, intermediate goods producers ripe a positive monopolistic profit.

The accumulation of productive physical capital, and therefore all investment decisions, are in the hands of the intermediate goods-producing firms. The capital accumulation equation takes the usual deterministic form, $k_t(i) = (1-\delta)k_{t-1}(i) + i_t(i)$, where $i_t(i)$ is gross investment into capital undertaken in period t. Firm production is described by the standard Cobb-Douglas function $y_t(i) = e^{\theta_t} k_{t-1}(i)^\gamma n_t(i)^{1-\gamma}$, where $\theta_t = \rho_\theta \theta_{t-1} + \varepsilon_t^\theta$ is a persistent disturbance to total factor productivity (TFP), with ε_t^θ white noise. Note that the period t capital stock of a firm, consisting of depreciated k_{t-1} and lately undertaken investment, will not be productive before the beginning of period $t+1$.

As revenues from the sale of intermediate output accrue at the end of period, whereas wages and investment into new productive capital have to be paid in advance, intermediate goods-producing firms are obliged to finance their working capital expenses through loans granted by the financial intermediaries. In real terms, firm i will borrow an amount of

$$\frac{L_t(i)}{P_t} = \frac{W_t}{P_t} n_t(i) + \frac{Q_t}{P_t} i_t(i).$$

For simplicity, the real value of productive capital $Q_t / P_t = q_t$ will be set equal to 1, i.e. final consumption and investment goods are identical, ex ante, and so are their prices.

We assume that, in equilibrium, defaulting on debt obligations is not an option. Screening and monitoring activities by the financial intermediaries exclude would-be firms from the credit market right from the start.

All intermediate firms are owned by the private households and do not accumulate own funds, apart from the stock of productive capital. At the end of each period, monopolistic profits g_t are therefore distributed to the representative household in the form of dividends. The risk-neutral manager of firm i chooses optimal values of $\{n_t(i), P_t(i), k_t(i)\}$ to maximise

$E_t \sum_{v=0}^{\infty} \beta^v \lambda_{t+v} g_{t+v}(i)$, where real current firm profits are

$$g_t(i) = \frac{P_t(i)}{P_t} y_t(i) - \frac{R_{t-1}^l (w_{t-1}(i) n_{t-1}(i) + i_{t-1}(i))}{\pi_t} - \frac{\phi_p}{2}\left(\frac{P_t(i)}{\pi P_{t-1}(i)} - 1\right)^2 y_t(i) - \frac{\phi_k}{2}\left(\frac{k_t(i)}{k_{t-1}(i)} - 1\right)^2 k_{t-1}(i),$$

subject to (at least) satisfying demand for intermediate good i by the final goods producer:

$$e^{\theta_t} k_{t-1}(i)^{\gamma} n_t(i)^{1-\gamma} \geq \left(\frac{P_t(i)}{P_t}\right)^{-\mu} y_t = y_t(i).$$

In the profit function, R_t^l is the per period gross loan rate demanded on working-capital loans. Following Rotemberg (1982), we assume that price-setting intermediate goods producers face quadratic adjustment costs when changing either their prices or their stock of physical capital. Positive capital adjustment costs imply that the value of installed productive capital to a firm may well lie above q_t which has been normalised to unity. As intuition suggests, both price and capital adjustment cost will be zero in the stationary equilibrium.

2.4 The Representative Final Goods-Producing Firm

The final goods producer operates in a perfectly competitive market, purchasing $y_t(i)$ units of the intermediate good i at the price $P_t(i)$ and assembling these inputs in the usual way to produce the final good

$$y_t = \left(\int_0^1 y_t(i)^{\frac{\mu-1}{\mu}}\right)^{\frac{\mu}{\mu-1}},$$

where μ is the elasticity of substitution between intermediate goods of different producers. The profit-maximising demand of the final goods producer for the intermediate good i is thus

$y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\mu} y_t$, with an aggregate price index $P_t = \left(\int_0^1 P_t(i)^{1-\mu} di\right)^{\frac{1}{1-\mu}}$.

2.5 Monopolistically Competitive Financial Intermediaries

Financial intermediaries, indexed to the interval $j = [0,1]$, provide slightly differentiated sight deposit and loan contracts, facing a constant finite elasticity of substitution in the markets for deposit and credit, respectively, of η_d and η_l. While, under perfect competition, R_t^d and R_t^l differ from the risk-free gross interest rate which is also the policy rate only by the marginal cost of "producing" deposits *(IMP)* and credit *(EFP)*, imperfect substitutability between the contracts of different banks will additionally lead to explicit monopolistic mark-ups or mark-downs on these rates, similar to the case of price-setters in goods production. In the present model, financial intermediaries are capable of changing their deposit and loan interest rates at a quadratic adjustment cost, which again disappears in the steady state.

A loan contract supplied by financial intermediary j is closed according the constant returns to scale function $l_t(j) = F\left(g_t + qk_t\right)^{\sigma}(e^{\chi_t}s_t(j))^{1-\sigma}$, where only monitoring effort s_t is costly. For simplicity, we assume that all banks are of comparable size, hold an equal share of the loan market, and serve an identical number of customers. The latter are distributed randomly among financial institutions. As a consequence, the amount of monitoring required to provide a line of credit $l_t(j)$ depends inversely on the value of economy-wide collateral. On the one hand, current period profits serve as collateral, and will not be distributed to the representative household as dividends until an intermediate goods-producing firm has honoured its debt. On the other hand, the financial intermediary can access the borrower's capital stock in case of default. Since k_t is installed in the enterprises as productive capital, however, only a constant fraction $q < 1$ is considered actually collectible by the bank. $\chi_t = \rho_\chi \chi_{t-1} + \varepsilon_t^\chi$ represents an auto-correlated disturbance to monitoring technology, later on referred to as *external finance premium (EFP) shock*, where ε_t^χ is a white noise shock.

The representative household is provided with liquidity services at a cost $\omega_t d_t(j)/m_t(j)$ that is proportionate to the amount of sight deposits and falling in the bank's reserves of central bank money. Financial intermediaries can increase their reserves of $m_t(j)$ by issuing risk-free bonds b which are bought by the monetary authority in open market operations in exchange for high-powered money. The mean-reverting marginal cost $\omega_t = \rho_\omega \omega_{t-1} + (1-\rho_\omega)\omega + \varepsilon_t^\omega$ is not specific to an institution. It sways around a long-run average value ω disturbed by a white noise term ε_t^ω, later on referred to as the *inside money premium (IMP) shock*. Since financial intermediaries are assumed to have access to the open capital or interbank market, where they can borrow at the risk-free interest rate R, they will not be prepared to pay an interest rate on sight deposits that lies above the risk-free rate, corrected for the cost of deposit provision. The difference between R_t and R_t^d is considered a liquidity premium, which will be referred to, in what follows, as the *inside money premium* or *IMP*.

The risk-neutral manager of financial intermediary j decides on $\{d_t(j), s_t(j), b_t(j), m_t(j)\}$ as well as on $\{R_t^d(j), R_t^l(j)\}$ to maximise $E_t \sum_{v=0}^{\infty} \beta^v \lambda_{t+v} g_{t+v}^f(j)$, where current profits are

$$g_t^f(j) = d_t(j) + b_t(j) + \frac{m_{t-1}(j)}{\pi_t} + \frac{l_{t-1}(j)R_{t-1}^l(j)}{\pi_t} - \frac{d_{t-1}(j)R_{t-1}^d(j)}{\pi_t} - \frac{b_{t-1}(j)R_{t-1}(j)}{\pi_t} - l_t(j) - m_t(j)$$
$$- w_t s_t(j) - \frac{\omega_t d_t(j)}{m_t(j)} - \frac{\phi_{R^d}}{2}\left(\frac{R_t^d(j)}{R_{t-1}^d(j)} - 1\right)^2 d_t(j) - \frac{\phi_{R^l}}{2}\left(\frac{R_t^l(j)}{R_{t-1}^l(j)} - 1\right)^2 l_t(j),$$

subject to $\quad d_t(j) \geq \left(\frac{R_t^d(j)}{R_t^d}\right)^{\eta_d} d_t \quad$ and $\quad l_t(j) \geq \left(\frac{R_t^l(j)}{R_t^l}\right)^{-\eta_l} l_t$

2.6 The Monetary Authority

We abstain from modelling a government, and thus from any kind of fiscal policy. However, we introduce an authority exercising monetary policy. Its highly stylised balance sheet merely contains high-powered money m on the liabilities side and bank bonds b on the asset side.

Every period, the monetary authority conducts open market operations to provide the financial intermediaries with their desired amount of central bank money in exchange for risk-free bank bonds. Since its assets yield a risk-free interest, while its liability, namely the money supply, doesn't, the central bank retains a positive seignorage profit from open market operations.

$$g_t^{cb} = m_t + \frac{b_{t-1}R_{t-1}}{\pi_t} - b_t - \frac{m_{t-1}}{\pi_t}$$

To avert a loss of these proceeds to the economy, we plainly assume that they are transferred to the representative private household as additional non-labour income.

Monetary policy is pursued by means of a simple standard Taylor (1993) rule,

$$R_t = (1-\rho)\left(\beta^{-1} + \varphi_\pi(\pi_t - 1)\right) + \rho R_{t-1} + r_t,$$

merely changing the risk-free gross nominal interest rate to offset deviations of current period inflation from its target value. For simplicity, we assume that the central bank targets price stability, i.e. a zero inflation rate, and that it tends toward interest rate inertia resulting from an aversion to fluctuations in the policy instrument $(0 < \rho < 1)$. The Taylor principle for stability will be fulfilled, if the central bank succeeds in raising the real interest rate in response to an inflationary shock (for a coefficient $\varphi_\pi > 1$). Strict pursuit of the rule is hindered by an auto-correlated shock term, $r_t = \rho_r r_{t-1} + \varepsilon_t^R$, which is beyond the control of the monetary authority.

3. Intertemporal Optimisation of Agents

3.1 Household Utility Maximisation

The first order conditions (FOCs), resulting from the representative household's optimisation problem, with respect to its choice variables are:

$$c_t: \qquad 1/c_t = \lambda_t + \xi_t \alpha_t$$

$$n_t, s_t: \qquad \phi = \lambda_t w_t$$

$$b_t: \qquad \lambda_t = \beta E_t \lambda_{t+1} \frac{R_t}{\pi_{t+1}}$$

$$d_t: \quad \left(1 + \phi_d \left(\frac{d_t}{d_{t-1}} - 1\right)\right)\lambda_t - \beta E_t \lambda_{t+1}\left[\phi_d \left(\frac{d_{t+1}}{d_t} - 1\right)\frac{d_{t+1}}{d_t} - \frac{\phi_d}{2}\left(\frac{d_{t+1}}{d_t} - 1\right)^2\right] = \beta E_t \lambda_{t+1} \frac{R_t^d}{\pi_{t+1}} + \xi_t .$$

These 4 equations together with the DIA constraint determine optimal household behaviour.

3.2 Profit Maximisation of Intermediate Goods Producers

The corresponding FOCs of the monopolistically competitive firms are:

$$n_t(i): \qquad \beta E_t \frac{\lambda_{t+1}}{\pi_{t+1}} R_t^l w_t = (1-\gamma)\Xi_t(i)\frac{y_t(i)}{n_t(i)}$$

$$P_t(i): \quad (1-\mu)\lambda_t + \mu \Xi_t + \mu \lambda_t \frac{\phi_p}{2}\left(\frac{\pi_t}{\pi} - 1\right)^2 = \lambda_t \phi_p \left(\frac{\pi_t}{\pi} - 1\right)\frac{\pi_t}{\pi} - \beta E_t \lambda_{t+1}\phi_p \left(\frac{\pi_{t+1}}{\pi} - 1\right)\frac{\pi_{t+1}}{\pi}\frac{y_{t+1}}{y_t}$$

$$k_t(i): \quad \beta^2 E_t \lambda_{t+2}\frac{R_{t+1}^l(1-\delta)}{\pi_{t+1}} - \beta E_t \lambda_{t+1}\frac{R_t^l}{\pi_{t+1}} + \beta E_t \lambda_{t+1}\phi_k \left(\frac{k_{t+1}(i)}{k_t(i)} - 1\right)\frac{k_{t+1}(i)}{k_t(i)} + \beta\gamma E_t \Xi_{t+1}\frac{y_{t+1}(i)}{k_t(i)} =$$

$$\lambda_t \phi_k \left(\frac{k_t(i)}{k_{t-1}(i)} - 1\right) + \beta E_t \lambda_{t+1}\frac{\phi_k}{2}\left(\frac{k_{t+1}(i)}{k_t(i)} - 1\right)^2$$

These conditions are completed by the capital accumulation equation and the Cobb-Douglas production function.

3.3 Profit Maximisation of Financial Intermediaries

Optimal behaviour of imperfectly competitive banks is prescribed by the following equations:

$d_t(j):$ $$\beta E_t \frac{\lambda_{t+1}}{\lambda_t}\frac{R_t^d(j)}{\pi_{t+1}} + \frac{\omega_t}{m_t(j)} = 1 + \frac{\lambda_t^1(j)}{\lambda_t} - \frac{\phi_{R^d}}{2}\left(\frac{R_t^d(j)}{R_{t-1}^d(j)} - 1\right)^2$$

$b_t(j):$ $$1 = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\frac{R_t}{\pi_{t+1}}$$

$s_t(j):$ $$\beta E_t \frac{\lambda_{t+1}}{\lambda_t}\frac{R_t^l(j)}{\pi_{t+1}} + \frac{\lambda_t^2(j)}{\lambda_t} = 1 + \frac{w_t s_t(j)}{(1-\sigma)l_t(j)} + \frac{\phi_{R^l}}{2}\left(\frac{R_t^l(j)}{R_{t-1}^l(j)} - 1\right)^2$$

$m_t(j):$ $$\beta E_t \frac{\lambda_{t+1}}{\lambda_t}\frac{1}{\pi_{t+1}} + \frac{\omega_t d_t(j)}{m_t(j)^2} = 1$$

By combining the financial intermediary's first and second FOC, we receive an expression for the inside money premium, namely the difference between interest paid on risk neutral bonds and the return of sight deposits placed with bank j.

$IMP_t:$ $$E_t \frac{\beta}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\left(R_t - R_t^d(j)\right) = \frac{\omega_t}{m_t(j)} - \frac{\lambda_t^1(j)}{\lambda_t} + \frac{\phi_{R^d}}{2}\left(\frac{R_t^d(j)}{R_{t-1}^d(j)} - 1\right)^2$$

Equivalently, we may substitute from ($b_t(j)$) into the first-order condition w.r.t. monitoring effort, obtaining an expression for the external finance premium. It quantifies the opportunity cost of intermediate goods-producing firms when relying on bank credit.

$EFP_t:$ $$E_t \frac{\beta}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\left(R_t^l(j) - R_t\right) = \frac{w_t s_t(j)}{(1-\sigma)l_t(j)} - \frac{\lambda_t^2(j)}{\lambda_t} + \frac{\phi_{R^l}}{2}\left(\frac{R_t^l(j)}{R_{t-1}^l(j)} - 1\right)^2$$

Finally, we can combine the FOCs w.r.t. high-powered money reserves and bonds and derive an explicit demand function for central bank money:

$$E_t \frac{\beta}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\left(R_t - 1\right) = \frac{\omega_t d_t(j)}{m_t(j)^2} \qquad \Leftrightarrow \qquad m_t(j) = \sqrt{\frac{\omega_t d_t(j)}{\beta(R_t - 1)E_t(1/\pi_{t+1})}}$$

The optimality conditions derived above are completed by the financial intermediaries' loan production function and the intermediate goods producers' credit requirement. Therefore, we implicitly assume that any demand for credit by firms will be satisfied in equilibrium.

In addition to these standard results, monopolistic competition in the banking sector involves a certain "price"-setting power. In this model, banks find themselves in the position to change their deposit and loan interest rates at the cost of a proportional loss in contractual partners. Accordingly, their optimal choices of R_t^d and R_t^l, respectively, must fulfil the following first-order conditions.

$$R_t^d(j): \quad \lambda_t\eta_d\left(\frac{R_t^d(j)}{R_t^d}\right)^{\eta_d-1}\frac{d_t}{R_t^d}-\beta E_t\lambda_{t+1}(1+\eta_d)\frac{d_t}{\pi_{t+1}}\left(\frac{R_t^d(j)}{R_t^d}\right)^{\eta_d}-\lambda_t\eta_d\left(\frac{R_t^d(j)}{R_t^d}\right)^{\eta_d-1}\frac{\omega_t d_t}{m_t(j)R_t^d}$$

$$-\lambda_t\phi_{R^d}\left(\frac{R_t^d(j)}{R_{t-1}^d(j)}-1\right)\left(\frac{R_t^d(j)}{R_t^d}\right)^{\eta_d}\frac{d_t}{R_{t-1}^d(j)}+\beta E_t\lambda_{t+1}\phi_{R^d}\left(\frac{R_{t+1}^d(j)}{R_t^d(j)}-1\right)\left(\frac{R_{t+1}^d(j)}{R_{t+1}^d}\right)^{\eta_d}\frac{R_{t+1}^d(j)}{R_t^d(j)^2}d_{t+1}$$

$$-\lambda_t\eta_d\frac{\phi_{R^d}}{2}\left(\frac{R_t^d(j)}{R_{t-1}^d(j)}-1\right)^2\left(\frac{R_t^d(j)}{R_t^d}\right)^{\eta_d-1}\frac{d_t}{R_t^d}-\lambda_t^1\eta_d\left(\frac{R_t^d(j)}{R_t^d}\right)^{\eta_d-1}\frac{d_t}{R_t^d}=0$$

$$R_t^l(j): \qquad \beta E_t\lambda_{t+1}(1-\eta_l)\frac{l_t}{\pi_{t+1}}\left(\frac{R_t^l(j)}{R_t^l}\right)^{-\eta_l}+\lambda_t\eta_l\left(\frac{R_t^l(j)}{R_t^l}\right)^{-\eta_l-1}\frac{l_t}{R_t^l}$$

$$-\lambda_t\phi_{R^l}\left(\frac{R_t^l(j)}{R_{t-1}^l(j)}-1\right)\left(\frac{R_t^l(j)}{R_t^l}\right)^{-\eta_l}\frac{l_t}{R_{t-1}^l(j)}+\lambda_t\eta_l\frac{\phi_{R^l}}{2}\left(\frac{R_t^l(j)}{R_{t-1}^l(j)}-1\right)^2\left(\frac{R_t^l(j)}{R_t^l}\right)^{-\eta_l-1}\frac{l_t}{R_t^l}$$

$$+\beta E_t\lambda_{t+1}\phi_{R^l}\left(\frac{R_{t+1}^l(j)}{R_t^l(j)}-1\right)\left(\frac{R_{t+1}^l(j)}{R_{t+1}^l}\right)^{-\eta_l}\frac{R_{t+1}^l(j)}{R_t^l(j)^2}l_{t+1}+\lambda_t^2\eta_l\left(\frac{R_t^l(j)}{R_t^l}\right)^{-\eta_l-1}\frac{l_t}{R_t^l}=0$$

The two equations are simplified, dividing them by the economy-wide average levels of sight deposits, d_t, or loan contracts, l_t, and by the marginal utility of household consumption, λ_t, as well as multiplying them by R_t^d and R_t^l, respectively.

4. The Symmetric Equilibrium

The competitive equilibrium is represented by an infinite sequence of the model's endogenous variables, where all economic agents optimise, the central bank follows its Taylor rule, and goods as well as financial contract markets clear.

For simplicity, we presume that the representative household holds zero bonds in equilibrium. Apart from that, the equilibrium conditions for the representative household and the monetary authority basically replicate their FOCs. This holds for the monopolistically competitive firms and banks, also. Though the latter benefit from quantifiable market power, leading to a price- and interest rate-setting behaviour, respectively, we will assume in the following that there is sufficient symmetry between these agents, that their factor demand and price-setting decisions will be identical in equilibrium. Under these symmetry assumptions, we receive the following system of 23 equations in 23 endogenous variables:

(1) $$1/c_t=\lambda_t+\xi_t\alpha_t$$

(2) $$\phi=\lambda_t w_t$$

(3) $$\lambda_t = \beta E_t \lambda_{t+1} \frac{R_t}{\pi_{t+1}}$$

(4) $$\left(1+\phi_d\left(\frac{d_t}{d_{t-1}}-1\right)\right)\lambda_t - \beta E_t \lambda_{t+1}\left[\phi_d\left(\frac{d_{t+1}{}^2}{d_t{}^2}-\frac{d_{t+1}}{d_t}\right)-\frac{\phi_d}{2}\left(\frac{d_{t+1}}{d_t}-1\right)^2\right] = \beta E_t \lambda_{t+1}\frac{R_t^d}{\pi_{t+1}}+\xi_t$$

(5) $$\alpha_t c_t = d_t$$

(6) $$k_t = (1-\delta)k_{t-1}+i_t$$

(7) $$y_t = e^{\theta_t} k_{t-1}{}^{\gamma} n_t{}^{1-\gamma}$$

(8) $$\beta E_t \frac{\lambda_{t+1}}{\pi_{t+1}} R_t^l w_t n_t = (1-\gamma)\Xi_t y_t$$

(9) $$(1-\mu)\lambda_t + \mu\Xi_t + \mu\lambda_t \frac{\phi_p}{2}\left(\frac{\pi_t}{\pi}-1\right)^2 = \lambda_t\phi_p\left(\frac{\pi_t^2}{\pi^2}-\frac{\pi_t}{\pi}\right)-\beta E_t\lambda_{t+1}\phi_p\left(\frac{\pi_{t+1}^2}{\pi^2}-\frac{\pi_{t+1}}{\pi}\right)\frac{y_{t+1}}{y_t}$$

(10) $$\beta^2 E_t \frac{\lambda_{t+2}}{\pi_{t+1}}(1-\delta)R_{t+1}^l - \beta E_t \frac{\lambda_{t+1}}{\pi_{t+1}} R_t^l + \beta E_t \lambda_{t+1}\phi_k\left(\frac{k_{t+1}^2}{k_t^2}-\frac{k_{t+1}}{k_t}\right)+\beta\gamma E_t \Xi_{t+1}\frac{y_{t+1}}{k_t} =$$
$$\lambda_t\phi_k\left(\frac{k_t}{k_{t-1}}-1\right)+\beta E_t\lambda_{t+1}\frac{\phi_k}{2}\left(\frac{k_{t+1}}{k_t}-1\right)^2$$

(11) $$g_t = y_t - \frac{R_{t-1}^l(w_{t-1}n_{t-1}+i_{t-1})}{\pi_t}-\frac{\phi_p}{2}\left(\frac{\pi_t}{\pi}-1\right)^2 y_t - \frac{\phi_k}{2}\left(\frac{k_t}{k_{t-1}}-1\right)^2 k_{t-1}$$

(12) $$R_t = (1-\rho)\left(\beta^{-1}+\varphi_\pi(\pi_t-1)\right)+\rho R_{t-1}+r_t$$

(13) $$g_t^{cb} = m_t + \frac{b_{t-1}R_{t-1}}{\pi_t} - b_t - \frac{m_{t-1}}{\pi_t}$$

(14) $$m_t = b_t$$

(15) $$g_t^f = d_t + b_t + \frac{m_{t-1}}{\pi_t}+\frac{l_{t-1}R_{t-1}^l}{\pi_t}-\frac{d_{t-1}R_{t-1}^d}{\pi_t}-\frac{b_{t-1}R_{t-1}}{\pi_t}-l_t-m_t-w_t s_t-\frac{\omega_t d_t}{m_t}$$
$$-\frac{\phi_{R^d}}{2}\left(\frac{R_t^d}{R_{t-1}^d}-1\right)^2 d_t - \frac{\phi_{R^l}}{2}\left(\frac{R_t^l}{R_{t-1}^l}-1\right)^2 l_t$$

(16) $$E_t \frac{\beta}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\left(R_t - R_t^d\right) = \frac{\omega_t}{m_t}-\frac{\lambda_t^1}{\lambda_t}$$

(17) $$E_t \frac{\beta}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\left(R_t^l - R_t\right) = \frac{w_t s_t}{(1-\sigma)l_t}-\frac{\lambda_t^2}{\lambda_t}$$

$$\textbf{(18)} \qquad E_t \frac{\beta}{\pi_{t+1}} \frac{\lambda_{t+1}}{\lambda_t}(R_t - 1) = \frac{\omega_t d_t}{m_t^{\ 2}}$$

$$\textbf{(19)} \qquad \eta_d d_t - \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1+\eta_d)\frac{d_t}{\pi_{t+1}} R_t^d - \eta_d \frac{\omega_t d_t}{m_t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \phi_{R^d}\left(\frac{R_{t+1}^{d\ 2}}{R_t^{d\,2}} - \frac{R_{t+1}^d}{R_t^d}\right) d_{t+1} =$$

$$\phi_{R^d}\left(\frac{R_t^{d\,2}}{R_{t-1}^{d\ 2}} - \frac{R_t^d}{R_{t-1}^d}\right) d_t + \eta_d \frac{\phi_{R^d}}{2}\left(\frac{R_t^d}{R_{t-1}^d} - 1\right)^2 d_t + \frac{\lambda_t^1}{\lambda_t}\eta_d d_t$$

$$\textbf{(20)} \qquad \eta_l l_t + \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1-\eta_l)\frac{l_t}{\pi_{t+1}} R_t^l + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \phi_{R^l}\left(\frac{R_{t+1}^{l\ 2}}{R_t^{l\,2}} - \frac{R_{t+1}^l}{R_t^l}\right) l_{t+1} =$$

$$\phi_{R^l}\left(\frac{R_t^{l\,2}}{R_{t-1}^{l\ 2}} - \frac{R_t^l}{R_{t-1}^l}\right) l_t - \eta_l \frac{\phi_{R^l}}{2}\left(\frac{R_t^l}{R_{t-1}^l} - 1\right)^2 l_t - \frac{\lambda_t^2}{\lambda_t}\eta_l l_t$$

$$\textbf{(21)} \qquad l_t = w_t n_t + i_t$$

$$\textbf{(22)} \qquad l_t = F(g_t + qk_t)^{\sigma}(e^{\chi_t} s_t)^{1-\sigma}$$

$$\textbf{(23)} \qquad c_t + d_t + \frac{\phi_d}{2}\left(\frac{d_t}{d_{t-1}} - 1\right)^2 d_{t-1} = w_t(n_t + s_t) + \frac{d_{t-1}R_{t-1}^d}{\pi_t} + g_t + g_t^f + g_t^{cb}.$$

5. Calibration and Steady-State Analysis

From the above system of equations, it is straightforward to compute the model's stationary equilibrium by ignoring the time indices on all variables. We assume that no random shocks occur in the steady state, so that the exogenous variables α_t, θ_t, χ_t, ω_t, and r_t take on their long-run trend values α, θ, χ, ω, and r which are equal to zero, in part. Due to the highly nonlinear nature of the model, a closed form analytical solution is not available. Instead, it must be solved numerically by means of the Gauss-Newton method using MATLAB routines. As far as possible, we calibrate our parameter set according to the existing literature. When it comes to parameters related to the banking sector, prior sources of information are rare. The calibration is thus geared to generate reasonable steady-state values of key financial variables.

5.1 Choice of Parameter Values

The discount factor β is set to a uniform quarterly value of 0.99255 for all economic agents. This corresponds to a real annual interest rate of about 3%. With a weight of leisure $\phi = 2.09$ in the utility function, the representative household spends close to 1/3 of its time endowment working in either intermediate goods-producing firms or banks. On average, a household must back up 80% of its consumption expenditure through sight deposits ($\alpha = 0.8$).

We set the income share of capital in goods production γ to a standard value of 0.35. Every period, the capital stock depreciates by $\delta = 2.5\%$. The price elasticity of intermediate-goods demand, $\mu = 6$, implies an average monopolistic mark-up over marginal costs of 20%.

Collateral, namely firm profits and physical capital, is relatively more productive in supplying loan contracts than in ordinary goods production, since even the most careful monitoring can not insure the lender against every foreseeable or unforeseeable risk of default. The higher the borrower's guarantee, the less informational effort must be undertaken by banks to provide a given amount of credit. Following Goodfriend and McCallum (2007), we set σ, the share of collateral in the representative financial intermediary's loan production, equal to 0.65. As the stock of physical capital is firmly installed in the firm, banks consider it to be recoverable and marketable only to an extent of $q = 0.2$. The set of credit related parameters is completed by a constant loan productivity coefficient $F = 5$. The marginal cost of providing deposit contracts is kept very low, i.e. $\omega = 0.00145$, to obtain reasonable steady-state interest-rate differentials. Finally, we must calibrate the interest-rate elasticity of deposit and loan contracts, η_d and η_l, respectively, which are fairly new in the New Keynesian/RBC literature. The only source of reference for these parameters is a paper by Gerali et al. (2008). It seems plausible that under heterogeneity among both goods producers and financial intermediaries, the services provided by different banks will be significantly less imperfectly substitutable against each other than the differentiated consumption or investment goods of a firm. We set $\eta_d = 500$ and $\eta_l = 385$, hence, while it should be noted that our values do by no means claim to set a benchmark.

5.2 The Stationary Equilibrium

As announced in the introduction to this chapter, the model can now be solved numerically. Under the parameterisation given above, we obtain the steady-state values listed in table 1.

Steady-State Values (*benchmark calibration*)								
y	c	i	k	n	s	R	R^d	R^l
1.0786	0.8353	0.2406	9.6260	0.3319	0.0014	1.0075	1.0025	1.0130
w	d	m	l	g	g^f	π	IMP	EFP
1.7507	0.6682	0.3606	0.8218	0.2462	0.0013	1.0000	0.0050	0.0055

Table 1: Steady-state results for a benchmark parameter calibration

From these values, several intuitive results can be derived. First of all, a consumption-to-GDP ratio c/y of 0.7744 and an investment-to-GDP ratio i/y of 0.2231 indicate that household consumption and capital investment make up for the lion's share of output, whereas not for all of it. 0.25% of GDP must be raised for the provision of liquidity services which causes sunk costs that are redistributed neither to bank employees in the form of wages nor to owners of sight deposits as interest payment. Note that this is not the case in loan production, where only screening and monitoring is costly. While this expenditure reduces a financial intermediary's profit and thus the dividends distributable to households, it simultaneously raises the salary of the latter. Excluding any default on debt in equilibrium, the collateral of borrowers will not be touched by banks either. As a result, there is no "loss" of resources as long as a constant line of credit is provided to intermediate goods-producing firms. Certainly, this may change, when the economy is destabilised by an exogenous disturbances.

Both banks and firms earn positive monopolistic profits in the steady state. These rents are distributed to the company owner, namely the representative household, as dividends.

Note that the stationary equilibrium has been computed for quarterly data at zero inflation. Consequently, the factors R, R^d, and R^l imply an approximate annual "real" interest rate on risk-free bonds, sight deposits, and loans, respectively, of 3%, 1%, and 5.2%, corresponding to a steady-state annual *IMP* of 2% and a steady-state annual *EFP* of 2.2%, exactly. What we have labelled *premium* is indeed the consequence of two special characteristics of this model. On the one hand, there is an intermediation cost in both the deposit and the credit market that can be passed down to bank customers by demanding an interest rate above the risk-free rate on funds lent out to intermediate goods-producing firms and by paying an interest rate below R_t on sight deposits. On the other hand, monopolistic competition in the markets for financial contracts allows banks to expand these interest rate differentials by manipulating their deposit or loan rate. Due to this monopolistic mark-up or mark-down on R^l and R^d, respectively, the representative financial intermediary earns a positive profit in the steady state.

For the *IMP* and *EFP* to disappear, banks would have to operate highly productive, supplying credit and liquidity services at zero cost, as well as perfectly competitive; and hence unable to reap any monopolistic profits. This represents an extension of the "highly efficient banking" case in Goodfriend and McCallum (2007). We approach our "highly efficient and competitive banking" scenario by increasing tenfold the loan productivity coefficient F to a value of 50, abandoning the marginal cost of deposit provision, $\omega = 0$, and setting the interest sensitivity of demand for financial contracts to a (theoretically) infinitely high value. The resulting new steady-state values are reproduced in the table 2.

Steady-State Values (*highly efficient and competitive banking)*								
y	c	i	k	n	s	R	R^d	R^l
1.0903	0.8430	0.2446	9.7825	0.3345	0.0000	1.0075	1.0075	1.0075
w	d	m	l	g	g^f	π	IMP	EFP
1.7654	0.6744	0.0000	0.8351	0.2489	0.0000	1.0000	0.0000	0.0000

Table 2: Steady-state results for an alternative calibration with $F = 50$, $\omega = 0$, $\eta_{d,l} = 100000$

With increased loan productivity, monitoring effort becomes almost superfluous; employment in the banking sector tends towards zero (note, that it is not identically equal to 0). Similarly, financial intermediaries do no longer hold significant reserves of central-bank money, when deposit provision is costless. In the absence of intermediation costs and monopolistic power, interest-rate differentials as well as bank profits will be approximately equal to zero.

6. Dynamic Analysis

6.1 Remaining Parameters

When calibrating the model for the steady-state analysis, parameters that did not play a role were left open for the time being. On the one hand, this concerns the entire set of adjustment cost coefficients. Since we assumed quadratic adjustment costs which have the convenient feature to disappeared in the stationary equilibrium, their calibration was postponed until now. The estimates proposed by the related literature for the capital adjustment cost coefficient ϕ_k range from around 10 up to 35, depending on the respective model specifications and sample period. Choosing a value of 35, we follow Ireland (2003) who receives a highly significant ϕ_k of 32.13 in a sticky price model for the post-1979 period. Similarly, we set the price rigidity coefficient to $\phi_p = 100$, a value in the mid range of Ireland's post-1979 estimates. The adjustment of real sight deposits by the representative household is assumed to be relatively less costly than that of firms' capital stock, i.e. $\phi_d = 30$. Finally, there are two parameters left for which we cannot resort to any empirical evidence. Since Gerali et al. (2008) do not justify their seemingly extreme calibration of the cost coefficients of deposit and credit interest-rate adjustment, it seems equally plausible to assume a degree of interest rate rigidity similar to that of intermediate goods prices. We therefore set $\phi_{R^d} = \phi_{R^l} = 100$.

On the other hand, the Taylor rule is yet to be specified numerically. As explained in section 2.6, central bank behaviour is characterised by an exclusive reaction to deviations of inflation from its zero target rate and by interest-rate inertia. Reluctant to sudden jumps in the policy rate, the central bank places a weight of $\rho = 0.5$ on R_{t-1}. To satisfy the Taylor principle, that is to raise the real interest rate in response to accelerated inflation, the monetary authority must increase the nominal interest rate by more than one percentage point for each percentage point increase in inflation. In line with Taylor's original proposal, we set the parameter φ_π to 1.5. Note that a calibration with $\varphi_\pi \leq 1$ does not satisfy the Blanchard-Kahn conditions, so the model becomes unstable and can no longer be solved by means of the B-K method.

Finally, there are the autoregressive coefficients and standard deviations of the five serially correlated shocks. Following Ireland (2003) and many others, we assume that these processes display significant persistence: $\rho_\alpha = 0.88$, $\rho_\theta = 0.95$, $\rho_\chi = 0.9$, $\rho_\omega = 0.9$, and $\rho_r = 0.75$. For the associated standard deviations of our normally distributed white noise disturbances, we chose $\sigma_\alpha = 0.6$, $\sigma_\theta = 0.8$, $\sigma_\chi = 0.8$, $\sigma_\omega = 0.18$, and $\sigma_r = 0.25$ in percentage terms, which implies that technological shocks in banking and intermediate-goods production are similarly highly auto-correlated and of identical average magnitude. Furthermore, a standard deviation disturbance of 25 basis points on a quarterly basis corresponds to a monetary policy shock in the order of one percentage point per annum. For the sake of clarity, table 3 in the appendix provides an overview of the entire set of benchmark parameter values.

6.2 The Model in Loglinear Form

The dynamic system of equations is solved and simulated in DYNARE on MATLAB. Since the model contains 10 so-called *jump-variables*, i.e. forward-looking endogenous variables, it must possess an identical number of eigenvalues outside the unit circle in order to fulfil the well-known Blanchard-Kahn conditions. As the algorithm is constrained to linear equations, the model must be loglinearised around the steady state. Below, $\hat{x}_t$ stands for the percentage deviation of variable x from its stationary equilibrium in period t. Note that the denotations of $\hat{R}_t$, $\hat{R}_t^d$, and $\hat{R}_t^l$ have a slightly different meaning: The interest rates on risk-free bonds, deposits, and loans enter the loglinear system in terms of absolute deviations from their steady states measured in percentage or basis points, respectively.

(1) $$0 = (1/c)\hat{c}_t + \lambda\hat{\lambda}_t + \xi\alpha\hat{\xi}_t + \alpha\xi\hat{\alpha}_t$$

(2) $$0 = \hat{w}_t + \hat{\lambda}_t$$

(3) $$0 = \hat{d}_t - \hat{c}_t - \hat{\alpha}_t$$

(4) $$0=\hat{k}_t-(1-\delta)\hat{k}_{t-1}-\delta\hat{i}_t$$

(5) $$0=\gamma\hat{k}_{t-1}+(1-\gamma)\hat{n}_t-\hat{y}_t+\hat{\theta}_t$$

(6) $$0=y\hat{y}_t-\frac{wn+i}{\pi}\hat{R}^l_{t-1}-\frac{R^l wn}{\pi}(\hat{w}_{t-1}+\hat{n}_{t-1})-\frac{R^l i}{\pi}\hat{i}_{t-1}+\frac{R^l(wn+i)}{\pi}\hat{\pi}_t-g\hat{g}_t$$

(7) $$0=d\hat{d}_t+b\hat{b}_t+\frac{m}{\pi}(\hat{m}_{t-1}-\hat{\pi}_t)+\frac{l}{\pi}\hat{R}^l_{t-1}+\frac{lR^l}{\pi}(\hat{l}_{t-1}-\hat{\pi}_t)-\frac{d}{\pi}\hat{R}^d_{t-1}-\frac{dR^d}{\pi}(\hat{d}_{t-1}-\hat{\pi}_{t-1})$$
$$-\frac{b}{\pi}\hat{R}_{t-1}-\frac{bR}{\pi}\left(\hat{b}_{t-1}-\hat{\pi}_t\right)-l\hat{l}_t-m\hat{m}_t-ws(\hat{w}_t+\hat{s}_t)-\frac{\omega d}{m}(\hat{\omega}_t+\hat{d}_t-\hat{m}_t)-g^f\hat{g}^f_t$$

(8) $$0=-\hat{R}_t+\rho\hat{R}_{t-1}+(1-\rho)\varphi_\pi\pi\hat{\pi}_t+r_t$$

(9) $$0=\hat{m}_t-\hat{b}_t$$

(10) $$0=m\hat{m}_t+\frac{b}{\pi}\hat{R}_{t-1}+\frac{bR}{\pi}\left(\hat{b}_{t-1}-\hat{\pi}_t\right)-b\hat{b}_t-\frac{m}{\pi}(\hat{m}_{t-1}-\hat{\pi}_t)-g^{cb}\hat{g}^{cb}_t$$

(11) $$0=wn(\hat{w}_t+\hat{n}_t)+i\hat{i}_t-l\hat{l}_t$$

(12) $$0=\frac{\sigma qk}{g+qk}\hat{k}_t+(1-\sigma)\hat{s}_t-l\hat{l}_t+\frac{\sigma g}{g+qk}\hat{g}_t+(1-\sigma)\hat{\chi}_t$$

(13) $$0=c\hat{c}_t+d\hat{d}_t-wn(\hat{w}_t+\hat{n}_t)-ws(\hat{w}_t+\hat{s}_t)-\frac{d}{\pi}\hat{R}^d_{t-1}-\frac{R^d d}{\pi}(\hat{d}_{t-1}-\hat{\pi}_t)$$
$$-g\hat{g}_t-g^f\hat{g}^f_t-g^{cb}\hat{g}^{cb}_t$$

(14) $$0=\beta\hat{R}_t-E_t\hat{\pi}_{t+1}+E_t\hat{\lambda}_{t+1}-\hat{\lambda}_t$$

(15) $$0=\beta\phi_d E_t\hat{d}_{t+1}-(1+\beta)\phi_d\hat{d}_t+\phi_d\hat{d}_{t-1}+\beta\frac{1}{\pi}\hat{R}^d_t-\beta\frac{R^d}{\pi}E_t\hat{\pi}_{t+1}+\beta\frac{R^d}{\pi}E_t\hat{\lambda}_{t+1}-\hat{\lambda}_t+\frac{\xi}{\lambda}\hat{\xi}_t$$

(16) $$0=(1-\mu)\hat{\lambda}_t+(\mu-1)\hat{\Xi}_t-\phi_p\hat{\pi}_t+\beta\phi_p E_t\hat{\pi}_{t+1}$$

(17) $$0=\hat{R}^l_t+E_t(\hat{\lambda}_{t+1}-\hat{\pi}_{t+1})+\hat{w}_t+\hat{n}_t-\hat{\Xi}_t-\hat{y}_t$$

(18) $$0=\beta\phi_k E_t\hat{k}_{t+1}-\left[(1+\beta)\phi_k+\beta\gamma\frac{\Xi}{\lambda}\frac{y}{k}\right]\hat{k}_t+\phi_k\hat{k}_{t-1}+\beta^2\frac{1-\delta}{\pi}R^l E_t(\hat{\lambda}_{t+2}-\hat{\pi}_{t+2})$$
$$+\beta\gamma\frac{\Xi}{\lambda}\frac{y}{k}E_t\hat{y}_{t+1}-\beta\frac{R^l}{\pi}E_t(\hat{\lambda}_{t+1}-\hat{\pi}_{t+1})+\beta\gamma\frac{\Xi}{\lambda}\frac{y}{k}E_t\hat{\Xi}_{t+1}-\frac{\beta}{\pi}\hat{R}^l_t$$

$$\textbf{(19)} \qquad 0 = \frac{\beta}{\pi}(\hat{R}_t - \hat{R}_t^d) - \frac{\beta}{\pi}\left(R - R^d\right)E_t(\hat{\pi}_{t+1} - \hat{\lambda}_{t+1} + \hat{\lambda}_t) - \frac{\omega}{m}(\hat{\omega}_t - \hat{m}_t) + \frac{\lambda^1}{\lambda}(\hat{\lambda}_t^1 - \hat{\lambda}_t)$$

$$\textbf{(20)} \qquad 0 = \frac{\beta}{\pi}(\hat{R}_t^l - \hat{R}_t) - \frac{\beta}{\pi}\left(R^l - R\right)E_t(\hat{\pi}_{t+1} - \hat{\lambda}_{t+1} + \hat{\lambda}_t) - \frac{ws}{(1-\sigma)l}(\hat{w}_t + \hat{s}_t - \hat{l}_t) + \frac{\lambda^2}{\lambda}(\hat{\lambda}_t^2 - \hat{\lambda}_t)$$

$$\textbf{(21)} \qquad 0 = \frac{\beta}{\pi}\hat{R}_t - \frac{\beta}{\pi}\left(R - 1\right)E_t(\hat{\pi}_{t+1} - \hat{\lambda}_{t+1} + \hat{\lambda}_t) - \frac{\omega d}{m^2}(\hat{\omega}_t + \hat{d}_t - 2\hat{m}_t)$$

$$\textbf{(22)} \qquad 0 = \beta\frac{\phi_{R^d}}{R^d}E_t\hat{R}_{t+1}^d + \left[\eta_d\left(1 - \frac{\omega}{m}\right) - \frac{\beta}{\pi}(1+\eta_d)R^d\right]\hat{d}_t - \left[(1+\beta)\frac{\phi_{R^d}}{R^d} + \frac{\beta}{\pi}(1+\eta_d)\right]\hat{R}_t^d$$

$$+ \eta_d\frac{\omega}{m}(\hat{m}_t - \hat{\omega}_t) + \frac{\phi_{R^d}}{R^d}\hat{R}_{t-1}^d + \frac{\beta}{\pi}(1+\eta_d)R^d E_t(\hat{\pi}_{t+1} - \hat{\lambda}_{t+1} + \hat{\lambda}_t) - \eta_d\frac{\lambda^1}{\lambda}(\hat{\lambda}_t^1 + \hat{d}_t - \hat{\lambda})$$

$$\textbf{(23)} \qquad 0 = \beta\frac{\phi_{R^l}}{R^l}E_t\hat{R}_{t+1}^l + \left[\eta_l + \frac{\beta}{\pi}(1-\eta_l)R^l\right]\hat{l}_t + \left[\frac{\beta}{\pi}(1-\eta_l) - (1+\beta)\frac{\phi_{R^l}}{R^l}\right]\hat{R}_t^l$$

$$+ \frac{\phi_{R^l}}{R^l}\hat{R}_{t-1}^l - \frac{\beta}{\pi}(1-\eta_l)R^l E_t(\hat{\pi}_{t+1} - \hat{\lambda}_{t+1} + \hat{\lambda}_t) + \eta_l\frac{\lambda^2}{\lambda}(\hat{\lambda}_t^2 + \hat{l}_t - \hat{\lambda}_t)$$

6.3 Results

The simulation findings are presented in two steps, beginning with an overview of the impacts of each of the model's exogenous disturbances on several important variables. The subsequent sensitivity analysis focuses on the influence of banking-related parameters on the transmission process of monetary policy.

6.3.1 Impulse Responses in the Baseline Model

This section gives an overview of the model's implications for the behaviour of key economic variables. The corresponding impulse response functions are displayed in the appendix.

Technology shock

Figure 5 maps the behaviour of selected variables after a one standard deviation disturbance to the technology parameter θ_t. Obviously, the shock generates a hump-shaped response in output which is 0.63 percent above its stationary equilibrium, 8 quarters later, before it starts to converge back. Being restricted by households' deposit holdings which are costly to adjust, consumption responds more gradually and reaches, hence, its maximum percentage deviation from steady-state of 0.48 after 3 years, only. Investment, in contrast, increases immediately by almost a quadruple of this. Whereas employment in goods production falls, on impact, due to a significant rise in the real wage, it overshoots the stationary equilibrium value to converge from above, once additional physical capital has been accumulated to an extent that increased labour productivity compensates for the higher wage rate.

Responding to the deceleration of inflation by 0.075 percentage points, the monetary authority mechanically relaxes its policy. At the end of year one, the quarterly risk-free interest rate has fallen by 5.2 basis points; corresponding to an easing of a quarter percent on an annual basis.

Naturally, the banking sector will be affected by a positive technology shock, as well. The immediate rise in investment expenditure by firms must be financed through additional loans. Employment in the banking sector will go up, accordingly. Due to the minuscule steady-state value, we regard the model's quantitative prediction of a two-percent increase in s with caution. While the direction of the overall changes in R^d and R^l is determined by the change in the policy rate, the exogenous disturbance's effect is more clearly visible in the *IMP* and *EFP*. With decreasing marginal productivity of monitoring effort, the financial intermediary must operate at higher marginal costs to satisfy the increased demand for credit contracts and will, therefore, demand a higher premium on top of the risk-free rate. Although more liquidity services are required, as economic activity and consumption expand, banks can provide them at a reduced cost due to higher reserves of central bank money m. Temporarily, the inside money premium falls by as much as 1.51 basis points.

Monetary Policy shock

We next analyse a positive 25 basis point deviation in quarterly r, equal to an increase of one percentage point per annum. With regard to the real side of our model economy, the standard qualitative effects can be observed. Restrictive monetary policy leads to a drop in GDP, consumption, and investment of 0.4, 0.2, and 1.45 percent, relative to the respective stationary equilibrium; employment in both goods production and banking falls significantly (see fig. 6).

At this point, the non-backward-looking nature of the intermediate goods producers' optimal price setting behaviour proves a bit unfortunate. Since the previous period's rate of inflation π_{t-1} is not predetermined, while the price level P_{t-1} clearly is, most of the shock to the Taylor rule is absorbed by an instantaneous deceleration of inflation. Nevertheless, we would like to emphasise that the impact on the *real* interest rate is the same, whether it originates from an increase in the nominal interest rate or from reduced inflation (expectations).

Monetary policy measures are destined to influence the inflation rate or the order of activity in an economy. It is thus of major interest, whether and to what extent the banking sector, i.e. the provider of "inside money" as well as working capital loans, will be affected by an increase in the monetary policy rate. A slow down in economic activity lowers the demand for financial intermediation. While liquidity services d go back by a mere 0.2 percent synchronously with consumption, the request for credit contracts l slumps by 1.65 percent relative to its steady-state value. For this reason, the prices of financial intermediation increase by less than the risk-free rate, resulting in a slightly higher interest differential to be earned on deposits, but a spread on the loan interest rate that falls by up to 1.68 basis points.

Deposit-in-Advance shock

The major part of a standard-deviation increase in the minimum amount of sight deposits per unit of consumption, α, is compensated by an immediate waiving of household consumption. The latter falls by 0.52 percent relative to its stationary equilibrium, because the adjustment of deposits is costly and satisfies the new liquidity requirement with a lag, only. The shortfall of private consumption lowers prices and deflates the currency (see figure 7). This leads to a rise in real labour costs and significant redundancies of almost 0.6 percentage points of steady-state employment. The simultaneous increase in investment expenditure by 0.12 percent is not sufficient to prevent a downturn in output and firm profits. Again, the central bank reacts by easing the policy rate to provide additional liquidity and stimulate economic activity.

While the loan interest rate follows on the heels of R, the deposit rate falls by somewhat less. A decline in the demand for credit by 0.33 percent forces banks to cut back on their wage bill. These redundancies are amplified by the continuous increase in intermediate goods producers' productive capital stock, also functioning as collateral. As a consequence, the *EFP* rises only marginally on impact, remaining close to but below its steady state afterwards. Similar to the case of a positive technology shock, the interest rate differential between R^d and the risk-free rate won't grow in response to a tightening of the DIA constraint. With high-powered money reserves increasing by 1.2 percent in the first and by another 0.3 percent in the second quarter, financial intermediaries can even provide liquidity services at a slightly reduced *IMP*.

Inside-Money-Premium shock

The two remaining exogenous disturbances originate directly from the banking sector and are, therefore, expected to have a minor influence on the economy's real variables.

The impulse responses of selected variables to an increase in ω, that instantaneously renders the provision of liquidity services d more costly, are depicted in figure 8. Commercial banks react by accumulating larger reserves of high-powered central bank money in order to limit the cost shock, which has a moderating effect on the *IMP*. As a result, the interest rate offered on sight deposits decreases by a mere 0.032 basis points relative to the steady state.

Nevertheless, any fall in R^d corresponds to an increase in the liquidity cost of consumption, and, hence, private households reduce their consumption expenditure as well as the amount of funds deposited with the financial intermediaries; however, to an equally small extent. Due to our log-separable specification of utility, this lower level implies a higher marginal utility of consumption and, from the logarithmised equation (2), a fall in the real wage w. Accordingly, the simulation predicts a negligibly small expansive effect on output, employment in goods production and banking, and inflation, while intermediate goods producing firms invest less. Following its Taylor rule, the monetary authority counteracts any inflationary tendency by moderately raising the policy rate. Note that all deviations in the impulse responses of real economy variables are of the order 10^{-4} or minor.

External-Finance-Premium shock

Finally, we expose the model to a disturbance in banks' screening and monitoring technology of σ_χ size. As expected, increased efficiency in loan production makes redundant part of the financial sector employees; s falls by 0.76 percent. Still, credit contracts can be provided at a lower cost which is passed on to customers as a reduction in the *EFP* by 0.29 basis points and a comparable drop in the loan interest rate R^l, illustrated in figure 9 in the appendix.

Intermediate goods producers make use of this cheaper source of funds by borrowing 0.0158 percent more working capital to expand employment and investment in productive capital by 1 and 2.8 basis points, respectively. It is due to the increased hiring of labour that firm output rises by 0.65 basis points, immediately, while the accelerated capital accumulation affects the production capacity with a lag, only. Private households, on the other hand, store additional funds in the form of sight deposits in order to finance higher consumption in the medium run. The outcome is a marginally elevated inside money premium.

An increased demand for goods – for consumption as well as investment purposes – induces an immediate inflation acceleration, although of a very limited extent. The monetary authority mechanically follows its Taylor rule, raising the policy rate by $3 \cdot 10^{-4}$ percentage points after 3 periods, at most, which suffices to ensure convergence back to the steady state. The deposit rate follows closely, only diverging by the *IMP*.

It is quite obvious that the influence of disturbances inherent to financial intermediation is of second order importance compared to that of the DIA, the monetary policy, and, especially, the technology shock in goods production. The present model contains two such shocks – one impeding the provision of liquidity services and one varying the efficiency in loan contracting – which affect output, consumption, investment, and the like through an *interest rate channel*.

By influencing the spreads between the deposit interest rate and the risk-free interest rate, and between the interest rate on credit and the risk-free interest rate, these shocks contribute to the economic agents' optimal decision making.

6.3.2 Monetary Policy and Financial Intermediation

The following section is destined to examine, whether and to what extent the effectiveness of monetary policy, performed by means of a simple Taylor rule, in this model, is sensitive to the calibration of several banking-related parameters. Since our focus of interest is to quantify, by how much the implementation of financial intermediaries amplifies or cushions the impact of changes in the policy rate on selected variables, the succeeding sensitivity analysis is confined to the impulse responses to a monetary policy shock, r_t.

The Impact of the Inside Money Premium

We begin by opposing a model with costless provision of liquidity services to two alternative versions with low and high *IMP*, respectively. Setting ω equal to 0, 0.00145, and 0.005, all three are simulated for 2000 periods in order to extract policy and transition functions as well as first and second order moments of the model's endogenous variables. Impulse responses of selected variables for the first 20 periods succeeding a contractionary monetary policy shock are depicted in figure 1.

For these moderate values of the parameter of interest, the size of the *IMP* has a marginal yet noticeable impact on the reactions of output and employment to an increase in r. The impulse responses of both display a diversification of up to 1.5 and 2.5 basis points, respectively, with regard to ω. This represents a fraction of 4.0 and 4.5 percent of the percentage deviation from stationary equilibrium, in year one after the shock. Moreover, the parameter plays a role in the representative household's optimal choice of consumption and, thus, sight deposits. It is not surprising that private agents will cut down on their consumption expenditure to an increasing degree after an economic slow down, if they receive less interest on the funds deposited with a financial intermediary. The lower R^d, the higher is the opportunity cost of liquidity services requisite for consumption. This interest differential, in turn, is significantly influenced by the size of the *IMP* coefficient which causes a maximum proportional difference of 3.1 percent in the impulse responses of consumption and bank deposits in period four following the shock.

Note that, because of our benchmark calibration which includes – as a decisive characteristic – a monopolistically competitive banking sector, the gap between the risk-free and the deposit interest rate will not even be closed completely, when $\omega = 0$.

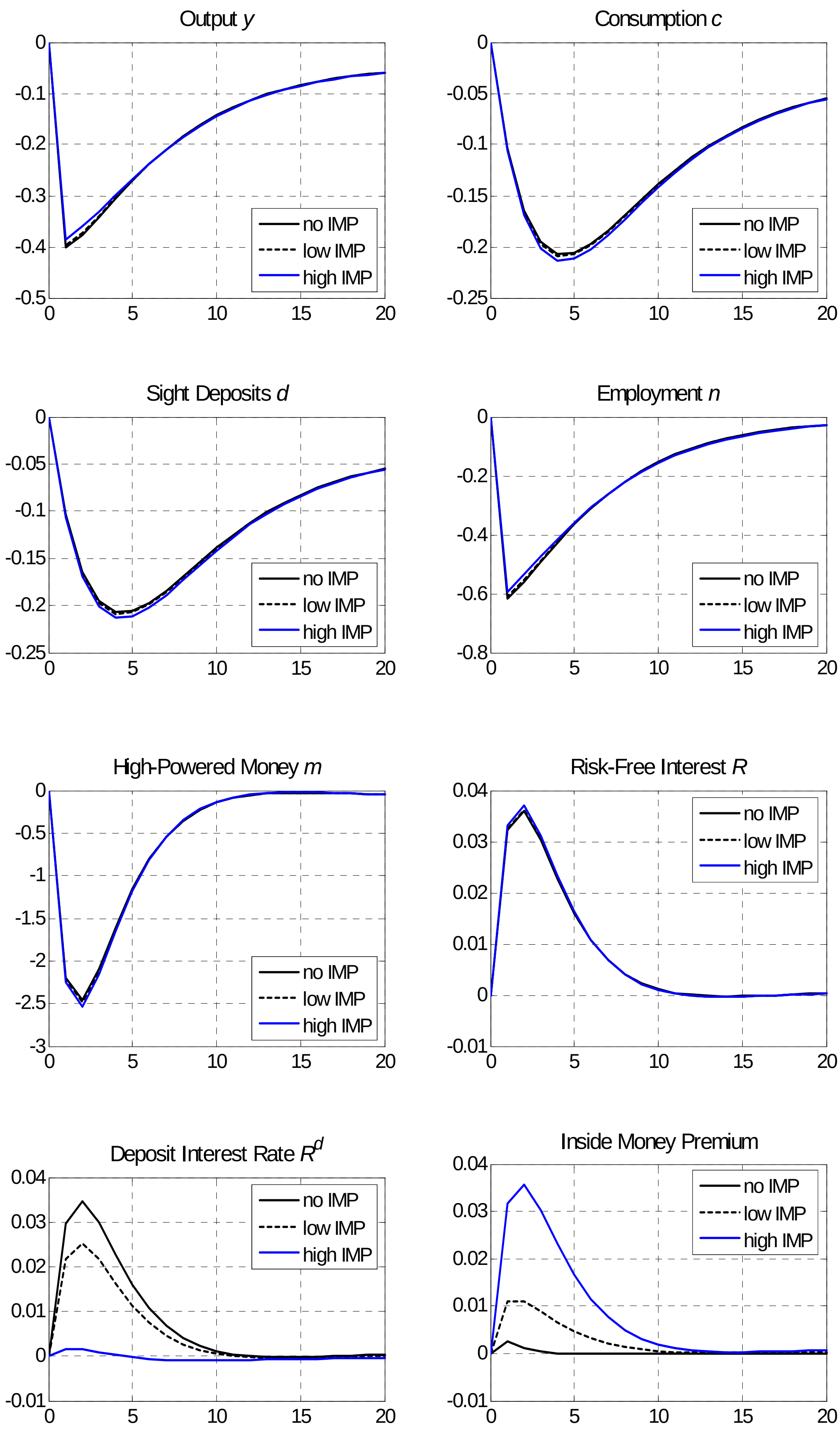

Figure 1: Impulse responses to a monetary policy disturbance for $\omega = 0$, 0.00145, and 0.005

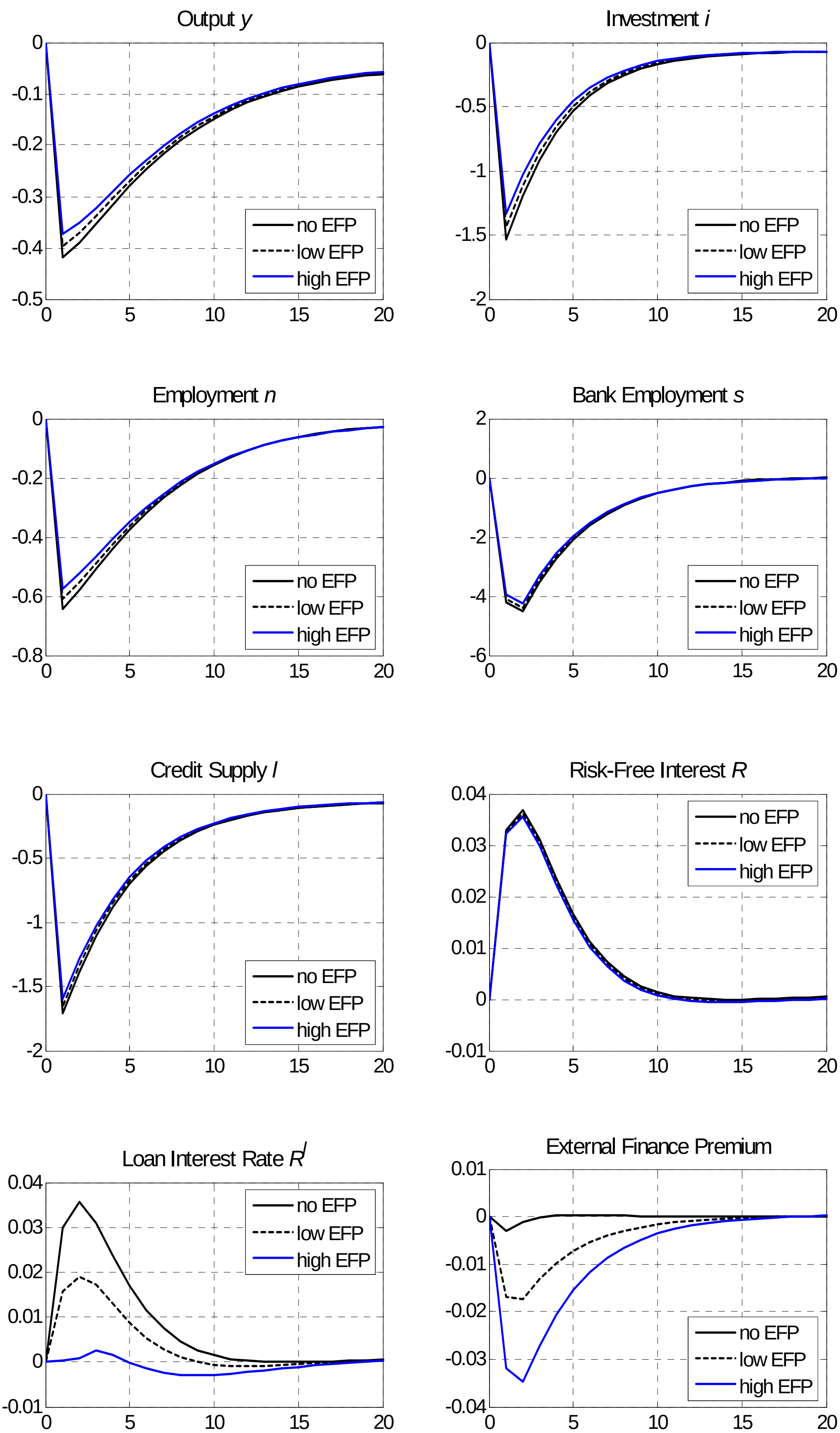

Figure 2: Impulse responses to a monetary policy disturbance for $s = 0$, 0.0014, and 0.003

Varying the External Finance Premium

The second essential characteristic of this model is an endogenous *EFP* designed along the lines of Goodfriend and McCallum (2007). This premium was brought down in the steady-state analysis through a sufficiently high value of the loan productivity coefficient F. Yet, in our model's linearised version, this latter constant has dropped out. We must therefore refute to the modification of steady-state employment in the banking sector, s, choosing values of 0, 0.0014, and 0.003, for an otherwise benchmark calibration, in order to approximate a setting with high, low, and no *EFP*. The resulting impulse responses are mapped above, in figure 2.

When this premium is switched off, R and R^l are almost perfectly positively correlated. The extent of this correlation falls with increasing steady-state monitoring. Due to the contractive effect of a higher policy rate on the labour input and investment expenditures of intermediate goods producers, the demand for working capital nosedives, leading to sizeable redundancies in the banking sector. The impact of the latter on the costs of financial intermediation will be the greater, the higher was the bank's monitoring effort in the stationary equilibrium, mirrored by obvious differences in the dynamics of the *EFP*. Depending on the parameter setting, the premium may remain virtually constant or decrease by up to 3.5 basis points. Accordingly, the loan interest rate tends to rise by less than the risk-free rate. For $s = 0.003$, we even observe a medium-run undershooting of the steady state value and thus a convergence from below. The percentage reduction in the amount of loans taken out ranges from 1.70 in the no-monitoring case, to 1.59 in the version with high monitoring; a difference of almost 7 percent.

The famous financial accelerator, introduced by Bernanke et al. (1999), is partly switched off in our model. As a consequence, it predicts that the presence of financial intermediaries may cushion the overall impact of a monetary policy shock on the real economy through the credit intermediation channel. The higher the steady-state interest-rate differential, the lower will be the increase in R^l and hence in the cost of acquiring additional working capital. Accordingly, the slow down in economic activity turns out to be less severe in case of a positive *EFP*. Its relevance for optimal inter-temporal behaviour is equally noticeable in the impulse responses of output, employment, and investment decisions of firms for $s = 0$, 0.0014, and 0.003, where we record differences of 10 percent or more in the deviations from the respective steady state values.

The Role of Competition in the Market for Deposits

Entirely new to the present model is the fact that financial intermediaries are granted a certain interest rate-setting power, similar to the price-setting power of monopolistically competitive

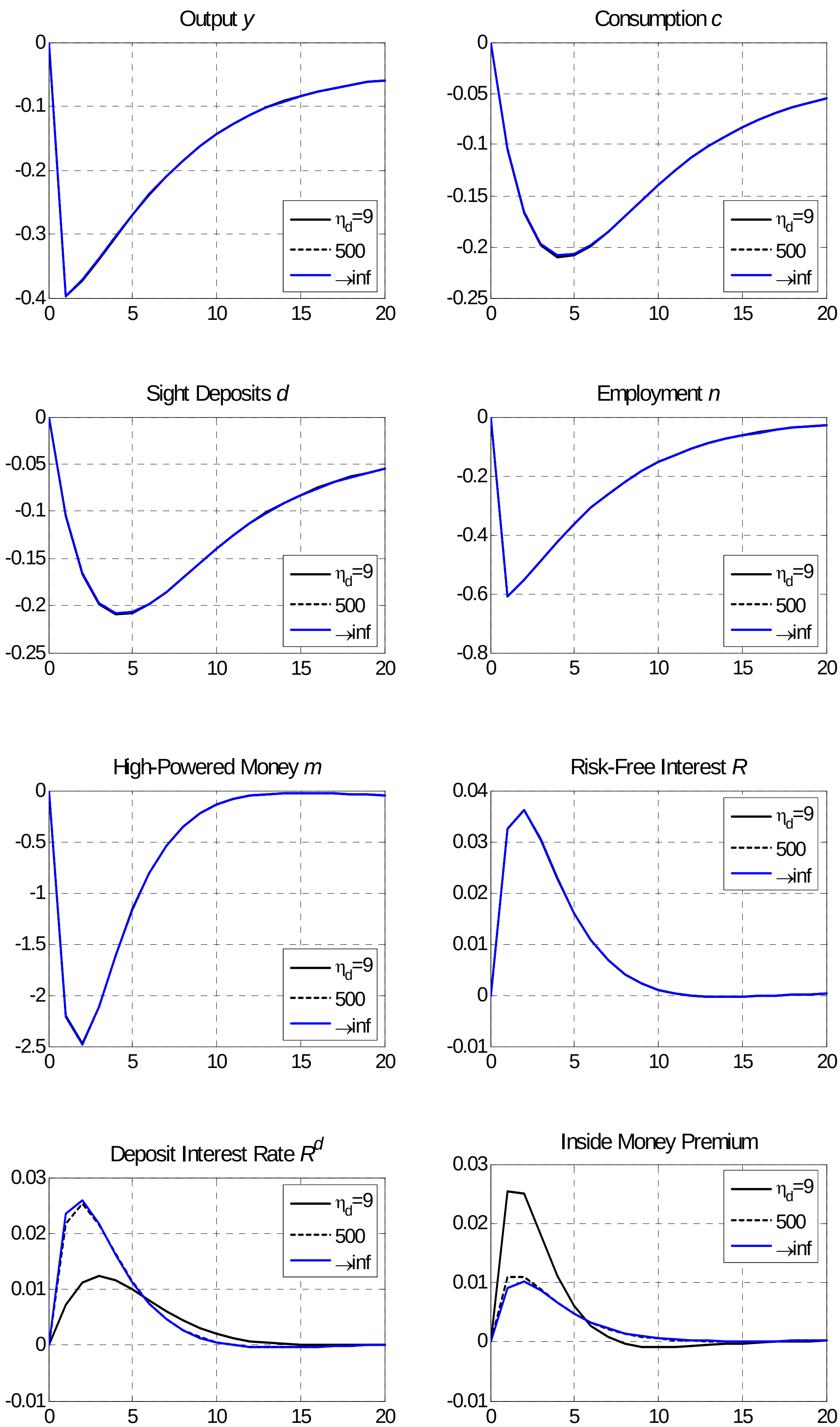

Figure 3: Impulse responses to a monetary policy disturbance for $\eta_d = 9$, 500, and $1 \cdot 10^{12}$

intermediate goods-producing firms. In what follows, the interest-rate sensitivity of demand for the deposits of a representative bank, η_d, has been set to 9, 500, and $1 \cdot 10^{12}$, to represent a highly monopolistic version, our benchmark case, and perfect competition, respectively, in the market for sight deposits. The corresponding simulation results are contained in figure 3.

While an interest rate mark-down of 12.5% on deposits is obviously unrealistically high, we picked this extreme value in order to exhaust the potential relevance of η_d.

Nevertheless, there is no recognisable effect of monopolistic competition in deposit provision on GDP and employment. This finding holds even for an unreasonably low degree of interest-rate sensitivity. An influence on private consumption and the demand for deposits is existent around the fourth quarter. However, it is clearly less important than that of the *IMP*, while the banks' optimal holdings of central bank reserves seem to be entirely unaffected.

We therefore focus on the impulse responses of R^d and of the interest rate differential. Under perfect competition, any variation in *IMP* is entirely due to fluctuations in the cost of deposit provision. Also for the benchmark calibration, $\eta_d = 500$, demand for liquidity services is still sensitive enough to trace closely the previous case. If financial intermediaries, conversely, operate in a market for deposits that is monopolistically competitive to a very high extent, benefiting from a measurable interest rate-setting power, the *IMP* shoots up in response to the monetary policy shock. Responding to the slow down in economic activity and lower demand for sight deposits, commercial banks increase the deposit interest rate more slowly and merely by about half the percentage point change we observe on a perfectly competitive market.

Clearly, it is optimal for banks to take advantage of their interest-rate setting power. While the impact on economic activity is only of the order 10^{-3} percentage points and not visible, unless impulse responses are magnified, limited competition among financial intermediaries in the market for deposits amplifies the contraction of the real economy subsequent to an increase in the monetary policy rate.

Altering Monopolistic Competition in the Credit Market

We conclude with a sensitivity analysis of the role of monopolistic competition in the market for loan contracts. Once more, the values of the parameter η_l are chosen in a way to reflect an exaggeratedly low, a benchmark, and an, at least approximately infinitely high substitutability of differentiated credit contracts; we therefore pick values of 9, 385, and $1 \cdot 10^{12}$.

It is apparent from the below figure that the structural composition of the credit market has a similarly weak influence on the economy's real side. When hit by an unanticipated monetary policy disturbance that drives up the risk-free interest rate, banks adjust their loan rate. Yet,

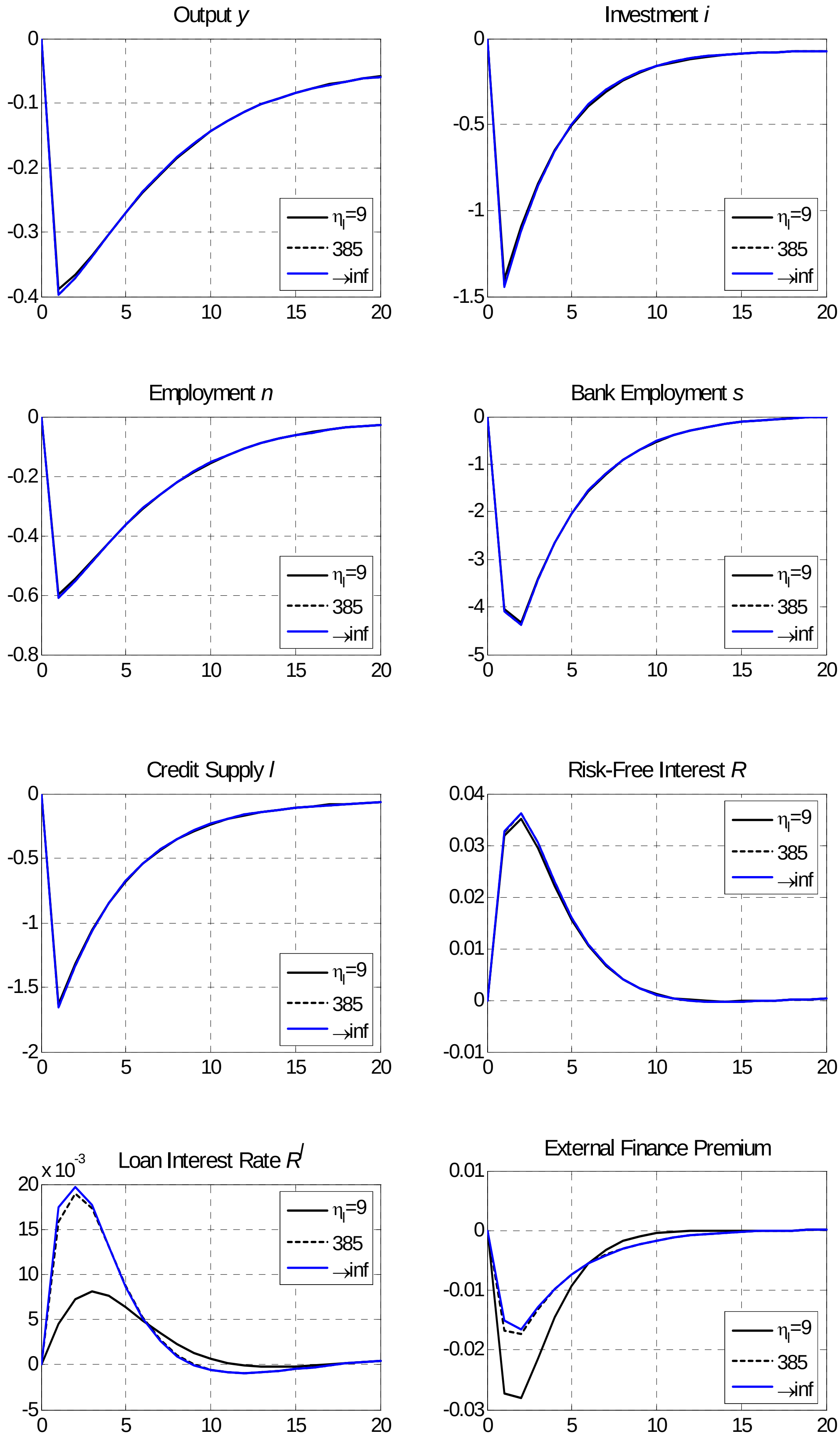

Figure 4: Impulse responses to a monetary policy disturbance for $\eta_l = 9$, 385, and $1 \cdot 10^{12}$

how closely they track the policy rate R, depends on two aspects: On the one hand, a falling real wage rate and reduced need for monitoring services, due to the drop in loan demand, lowers the cost of credit intermediation. On the other hand, the monopolistically competitive bank managers incorporate profit considerations and shareholder concerns in their interest rate setting behaviour. As a result, the negative correlation between the demand for and interest rate on loans diminishes jointly with η_l. In their attempt to minimise the loss of borrowers, monopolistically competitive banks utilise their interest rate-setting power, accepting a higher temporary reduction in the *EFP* than under perfect competition. For the case of an overly low interest sensitivity, the model predicts a maximum increase in R^l of 0.8 basis points, opposed by almost 2 basis points for $\eta_l \to \infty$. This corresponds to a percentage deviation from steady state of two and a half times the size. Even when the coefficient is set to its benchmark value, optimising behaviour would still invite banks to adjust their loan interest rate only imperfectly in response to an increase in R.

According to our model, endowing financial intermediaries with market power attenuates the effect of a contractionary monetary policy shock. While we already remarked that the degree of competition in the market for credit contracts was of second order importance, its influence seems to be at least ten times larger, on average, than that of competition among providers of liquidity. The impulse responses of output and employment for $\eta_l = 9$ and $\eta_l \to \infty$ differ by approximately 1 basis point, on impact; that of loans taken out by up to 2.5 basis points. In line with empirical evidence, investment into productive capital displays the highest interest sensitivity, with instantaneous deviations from the steady state ranging from -1.40 to -1.44 percent; a divergence of almost 3 percent.

Once again, we would like to emphasise that the preceding sensitivity analysis unambiguously attests monopolistic competition in the loan market to function as a, maybe negligible, shock absorber with regard to monetary policy. As a result, the economy's real variables will deviate from their steady-state values to a minor extent, when banks can act as interest-rate makers.

7. Conclusion

In the model presented in this paper, private economic agents rely on financial intermediation. On the one hand, intermediate goods-producing firms can not accumulate financial resources between periods and are therefore forced to take out loans in order to fund their present-period working capital. On the other hand, private households must prove their credit worthiness or, more accurately, their liquidity in a varying share of consumer purchases, by saving part of labour and dividend income in the form of sight deposits.

These services are provided by financial intermediaries operating in the credit and the deposit market, at the same time. Banks hire monitoring effort and require collateral, composed of the applicants' expected profits and productive capital stock, to ensure that no firm defaults on its loan. Moreover, the administration of sight deposits by the bank causes costs that depend on a fluctuating marginal-cost coefficient, increase proportionally with the amount of deposits, and fall in the bank's reserves of high-powered central bank money.

The costs of financial intermediation largely determine the interest rate differentials between the risk-free refinancing rate and the deposit and credit interest rate, respectively, namely the so-called *inside money premium* and *external finance premium*. Consequently, both premiums are entirely endogenous in our model. In addition, we assume bank products to be imperfectly substitutable against each other. With monopolistically competitive markets for deposit and credit contracts, we grant banks a certain interest rate-setting power through their influence on the *IMP* and *EFP*.

The results are partly in line with the related literature but also partly astonishing. First, each of the two shocks inherent to the banking sector seems to be of minor order importance when compared to a standard technology shock, the monetary policy disturbance, or the DIA shock. However, the specific framework is not flexible enough to simulate a severe financial crisis, like the present credit crunch, which might lead to more significant theoretical impacts. This certainly is an interesting direction for further model refinements.

The subsequent sensitivity analysis of impulse responses to a contractionary monetary policy shock predicts that a high *IMP* coefficient amplifies the optimal reaction of consumers, while it cushions the percentage deviation of output and employment from their steady-state values. Increasing the value of the *EMP* parameter unambiguously moderates the extent of economic contraction following a rise in the monetary policy rate, as the loan interest rate remains more or less constant. Finally, we analysed the relevance of competition in the markets for deposits and loans. Somewhat surprisingly, monopolistic competition among the suppliers of liquidity services acts as a financial accelerator, whereas the heterogeneity of credit contracts absorbs part of the adverse effect of a contractionary monetary policy disturbance. While the degree of competition on either market merely has a marginal influence on the behaviour of economic agents, the interest-rate sensitivity of demand for loans is obviously the more important one.

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Appendix. Additional tables and figures

Parameter Values *(benchmark calibration)*			
Coefficient	Value	Coefficient	Value
α	0.8	ϕ_{R^d}	100
β	0.99255	ϕ_{R^l}	100
γ	0.35	ρ	0.50
δ	0.025	ϕ_π	1.50
ϕ	2.0875	ρ_r	0.75
ω	0.00145	σ_r	0.25
σ	0.65	ρ_θ	0.95
F	5	σ_θ	0.80
q	0.20	ρ_α	0.88
μ	6	σ_α	0.60
η_d	500	ρ_ω	0.90
η_l	385	σ_ω	0.18
ϕ_k	35	ρ_χ	0.90
ϕ_p	100	σ_χ	0.80
ϕ_d	30		

Table 3: Benchmark calibration of all model parameters relevant for the economy's steady state and dynamic behaviour

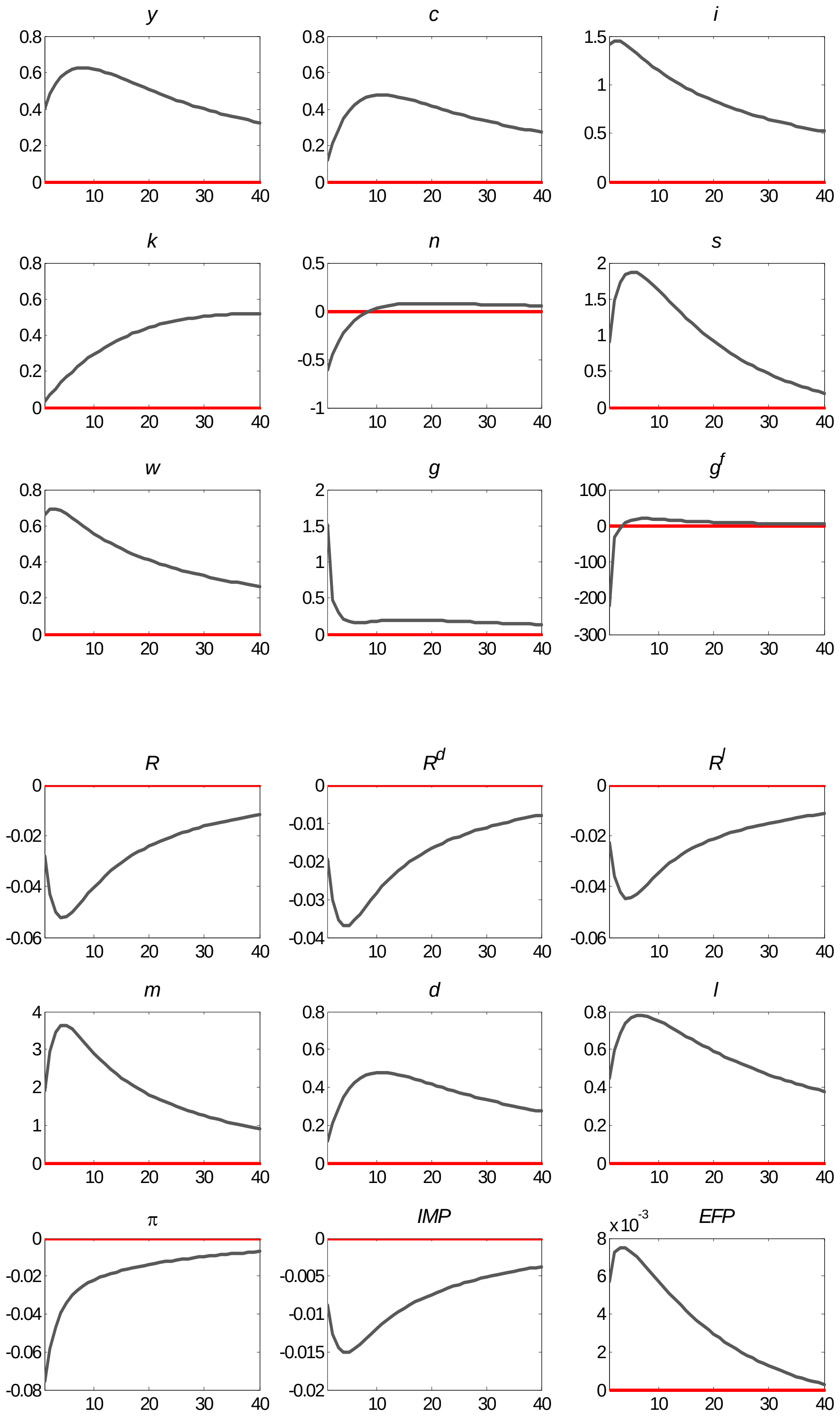

Figure 5: Selected impulse responses to an orthogonalised technology shock θ in goods production

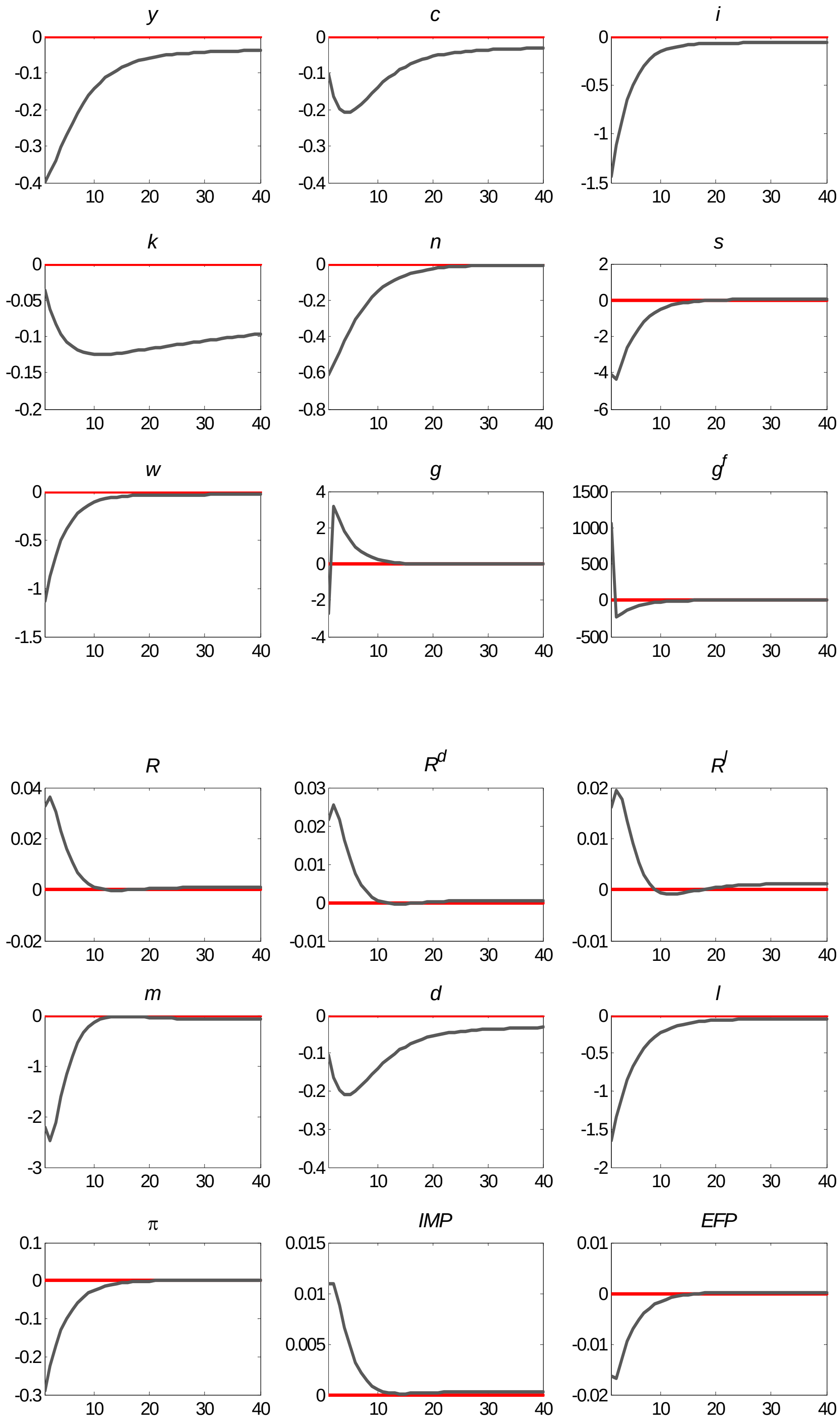

Figure 6: Selected impulse responses to an orthogonalised shock r to the monetary policy rate

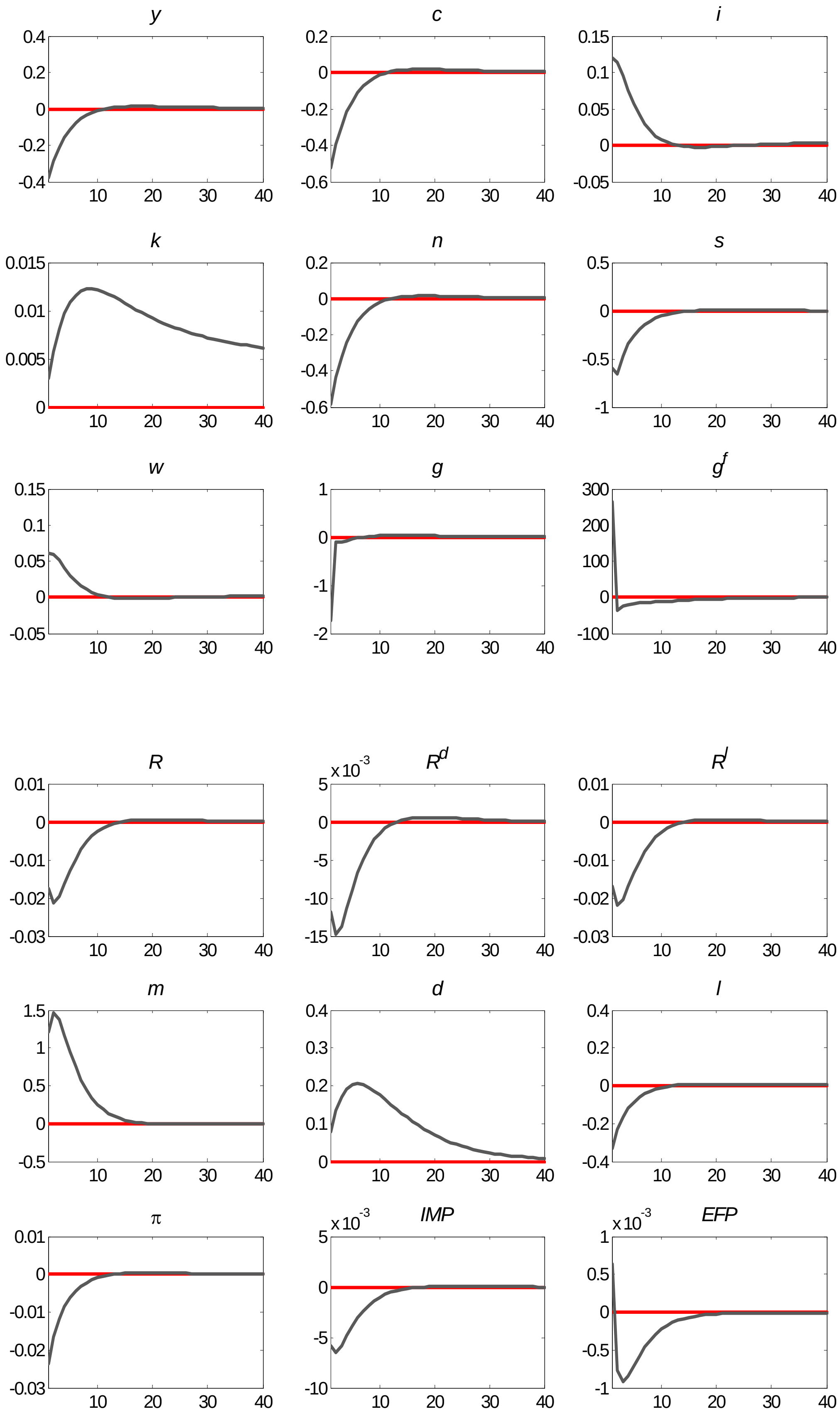

Figure 7: Selected impulse responses to an orthogonalised Deposit-in-Advance disturbance α

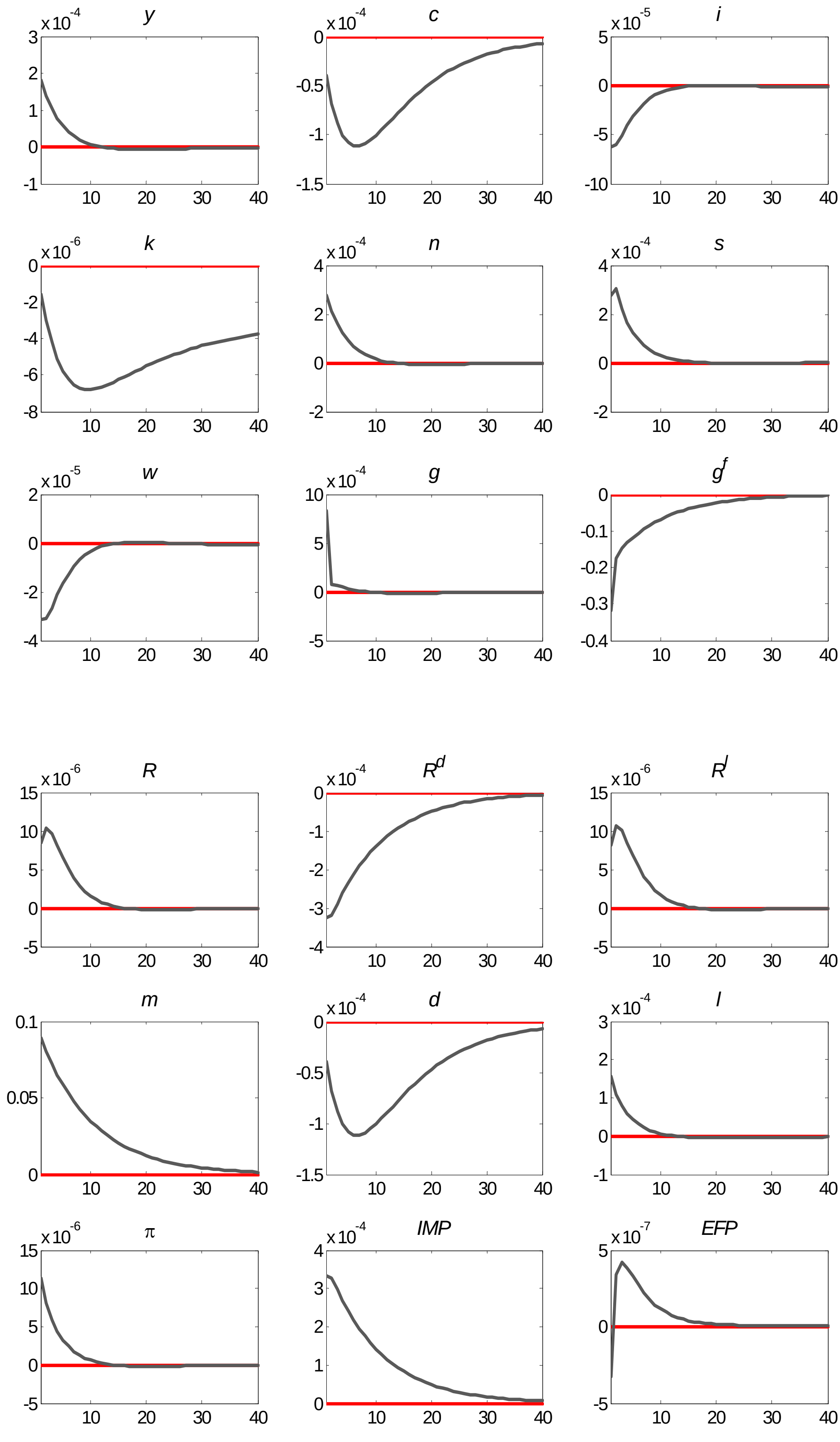

Figure 8: Selected impulse responses to an orthogonalised Inside Money Premium shock ω

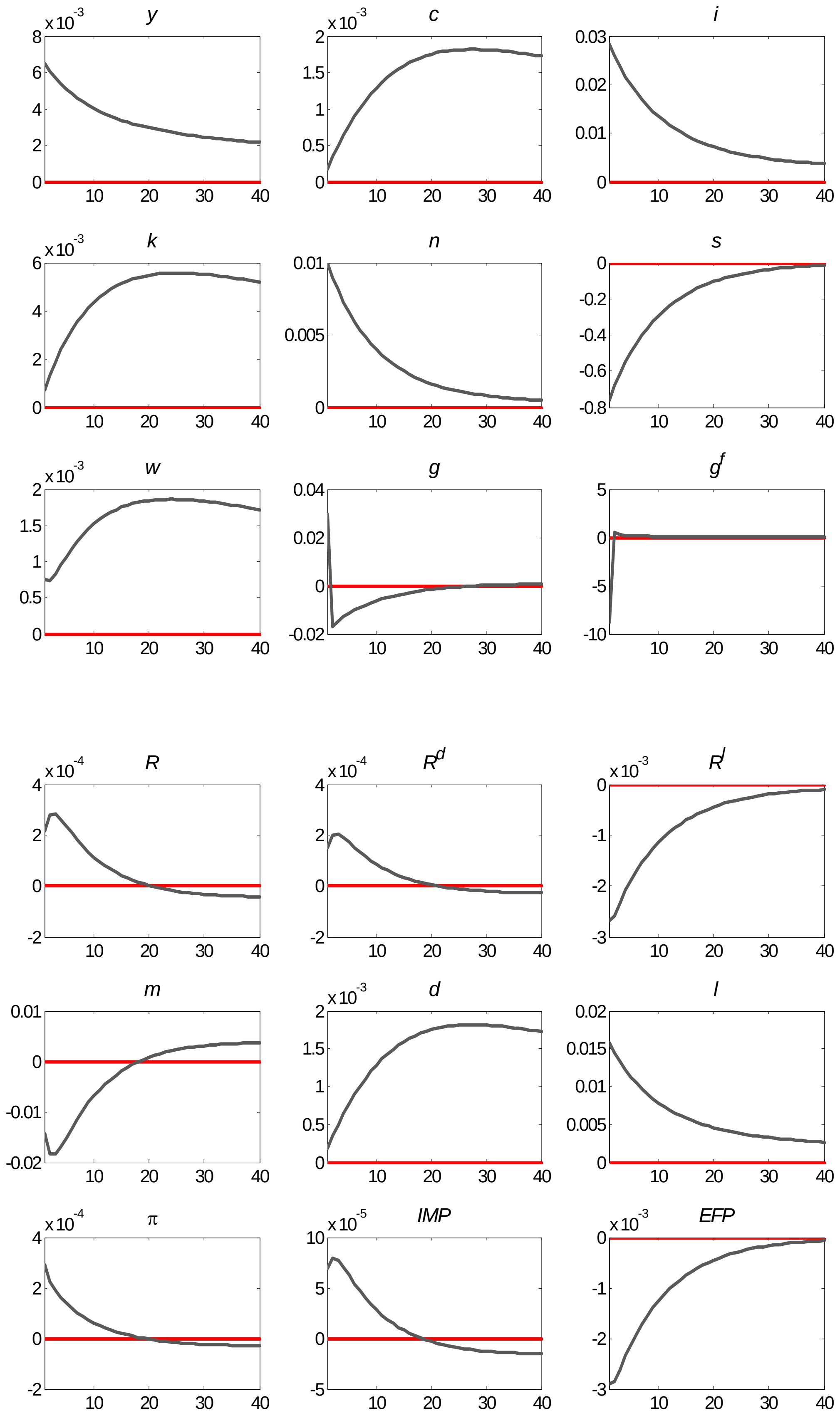

Figure 9: Selected impulse responses to an orthogonalised shock χ to the External Finance Premium