Monetary and Fiscal Policy in a Financial Accelerator Model

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Abstract: The paper at hand develops a dynamic stochastic general equlibrium (DSGE) model in order to examine the recent policy measures which were undertaken during the financial crisis that has started in 2007. Based on existing literature, we extend the standard New Keynesian framework by incorporating financial frictions and a richly specified financial sector. In our model, monetary policy can be both conducted by a standard Taylor rule mechanism in non-crisis times and the facilitation of lending in times of a crisis. Fiscal policy, in turn, is passively modeled via fiscal rules which respond to output and debt changes. The fiscal policy parameters are then estimated for the Euro Zone from 1980 to 2011. We show that by intervening on capital markets and by expanding fiscal activity in times of a crisis, the government and/or central bank are able to reduce the deterioration of assets severely. They are able to considerably lower the negative effect on overall economic activity. The main driver is the unconventional intervention of the central bank. Fiscal stimuli also reduce the impact of a financial crisis, but with a lower magnitude. Eventually, the combination of both instruments is investigated and results show that this yields the most significant recession easing effect.

Keywords:	DSGE model, financial crisis, financial accelerator unconventional monetary policy, fiscal policy, bayesian estimation
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1 Introduction

The financial crisis which started in 2007 and which had its origins in the US was one of the most severe economic crises in the last decades, even in the last centuries. It has brought up that standard macroeconomic models had failed in explaining or predicting the crisis. Conventional monetary policy as well as fiscal stimulus packages have not been enough to combat the financial crisis. Therefore, adjustments in the established macroeconomic theory are necessary to get a more surround understanding of this phenomena.

Until the mid-1990s models assumed frictionless financial markets, in which households, firms and banks could borrow or lend infinitely. By introducing financial frictions the amount which agents can borrow will be limited and, in addition, interest rate spreads between risky and risk-free assets can be modeled. Thereafter, by abandoning the assumption of frictionless financial markets, these modified DSGE models were able to capture the recent increase in interest rate spreads. Further, besides the issue of financial frictions, models which primarily focused on monetary policy often disregarded fiscal policy as another important policy tool. Models, in turn, that featured a richly specified fiscal sector did not take into account financial frictions. This research addresses the aforementioned problems by combining the insights of both research areas. Moreover, by estimating the extended model for the Euro Zone with data from 1980 to 2011, it evaluates the effectiveness of unconventional monetary policy and anti-cyclical fiscal policy.

The first landmark in the field of models which abandon the assumption of frictionless financial markets was published by Bernanke, Gertler, and Gilchrist (1999). Their model endogenizes credit markets by introducing an agency problem between borrowers and lenders. They show that this financial accelerator propagation mechanism has significant influence on business cycle dynamics. Based on New Keynesian models of Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2007), Gertler and Karadi (2011) extend these models by incorporating banks as financial intermediaries. By doing so, they show that financial frictions in terms of banks have a significant impact on overall economic activity in times of a crisis. Further, the monetary authority can conduct unconventional monetary policy, i.e. it can provide funds to banks in a crisis. We extend this framework by expanding investment opportunities for banks.

A paper which analyses the role of fiscal policy in an extended DSGE model was published by Coenen, Straub, and Trabandt (2013). The basic framework for their analysis is the New Area Wide Model (NAWM) which is used by the European Central Bank (ECB). They extend the NAWM by a richly specified fiscal sector, i.e. they introduce several channels through which the government can influence economic activity. This is done by assuming feedback rules for fiscal variables. However, this model lacks in modeling the financial sector. We, now, combine both insights.

The remainder of this paper is structured as follows. In Section 2 we provide a summary of the main features of the model, while the data is presented in Section 3. The empirical strategy is presented in Section 4. Section 5 studies the main results and Section 6 closes with a conclusion.

2 The Model

In this section we present the model. As mentioned, the model features elements that are standard as well as elements which are based on contributions from Gertler and Karadi (2011), Kirchner (2011) and Coenen, Straub, and Trabandt (2013). The baseline version is a New Keynesian Financial Accelerator Model presented by Gertler and Karadi (2011). As standard DSGE models, it does not only consist of four types of agents, namely households, non-financial firms, a fiscal authority, and a monetary authority, but also of banks which act as financial intermediaries between all agents.

2.1 Households

There is a continuum of identical households of measure unity, the representative household. Households' members can be either workers or bankers. So, there is a certain fraction of households' members that are bankers and another fraction that are workers. A banker stays a banker in the next period with probability θ, resulting in the average survival time for a banker as being $\frac{1}{1-\theta}$. Consequently, the households own the banks they lend money to. They also earn the profits which the bank generates. The decision problem of the representative household is to maximize the expected sum of discounted lifetime utility which is given by

$$\max_{C_t, D_{t+1}, L_t} E_t \left\{ \sum_{i=0}^{\infty} \beta^i \epsilon_{t+i}^p \left[ln\left(C_{t+i} - hC_{t+i-1}\right) - \frac{\chi}{1+\varphi} \epsilon_{t+i}^l L_{t+i}^{1+\varphi} \right] \right\} \tag{1}$$

with C_t being consumption, L_t labor supply, β the subjective discount factor ranging between $0 < \beta < 1$, h the habit formation parameter with $0 < h < 1$, φ the degree of convexity of labour disutility, χ the relative utility weight of labour, and ϵ_t^p and ϵ_t^l shocks to consumption preferences and labor disutility, respectively.

Consumption dynamics are captured via the log difference in utility out of consumption in t and $t-1$. So not only current consumption is important, but also past consumption, which essentially yields to intertemporal consumption smoothing.

Moreover, although a model which analyzes the effect of monetary policy is developed, money is not included in the utility function of households. This approach in contrast to classical monetary economics is preferably used in Woodford (2003) and Williamson (2008). Money does not serve as a medium of exchange and is not held in equilibrium. This is also reflected in the budget constraint of the household, where consumption C_t is denominated in real terms. Thereafter, the households maximizes (1) with respect to

$$(1+\tau_t^c)C_t + D_{t+1} = (1-\tau_t^l-\tau_t^{ssh})W_tL_t + \Pi_t + TR_t + R_{dt}D_t \tag{2}$$

with D_t intermediary deposits, R_{dt} the interest rate on intermediary deposits, W_tL_t labor income, Π_t profits and TR_t lump-sum fiscal transfers. Households have to pay taxes on consumption and labor with the tax rates τ_t^c on consumption, τ_t^l and τ_t^{ssh} on labor, where τ_t^{ssh} are defined as social security contributions by employees. This results in the following optimality conditions

Marginal Utility of Consumption:

$$\varrho_t = \frac{1}{1+\tau_t^c}\left[\epsilon_t^p\left(C_t-hC_{t-1}\right)^{-1} - \beta h\epsilon_{t+1}^p E_t\left(C_{t+1}-hC_t\right)^{-1}\right] \tag{3}$$

labor-Leisure Trade Off:

$$W_t = \frac{\epsilon_t^l\chi}{\varrho_t\left(1-\tau_t^l-\tau_t^{ssh}\right)}L_t^{\varphi} \tag{4}$$

Euler Equation:

$$\beta E_t\{\Lambda_{t,t+1}R_{dt+1}\} = 1. \tag{5}$$

Equation (3) represents the marginal utility of consumption, equation (4) the intratemporal labor-leisure trade off and expression (5) denotes the intertemporal consumption Euler equation.

2.2 Non-Financial Firms

Let us now switch to the production and investment side of the economy. Subsequently, we present the main objectives of these agents, starting with intermediate goods producing firms.

2.2.1 Intermediate Goods Producing Firms

Intermediate goods producing firms produce a certain output which is sold to retailers. They produce on a competitive market via the production technology

$$Y_t = A_t \left(U_t \xi_t K_{t-1}\right)^{\alpha} L_t^{1-\alpha} \tag{6}$$

with A_t being the total factor productivity, U_t the capital utilization rate, ξ_t the quality of capital and therefore $\xi_t K_t$ the effective quality of capital, L_t labor, and α the capital share.

Intermediate goods producing firms produce with two inputs, labor and capital. To finance the capital acquisition which is needed for production, intermediate goods producing firms issue claims S_t equal to the amount of capital they want to buy. Every claim is worth the relative price Q_t. The claim pays a return R_{kt+1} in $t+1$. At the end of the period, the firm sells the depreciated, effective capital stock $(1-\delta(U_t))\xi_t K_t$ for a price Q_{t+1}. Further, firms pay out the exogenously given real wage W_t plus contributions for social security for labor input. Hence, intermediate goods producing firms maximize the expected, discounted profit function $\sum_{i=0}^{\infty} \beta^i \Lambda_{t,t+i} \Pi_{t+i}$ with respect to U_t, L_t, and K_t. Formally:

$$\begin{aligned} \max_{U_t, L_t, K_t} E_t \Bigg\{ \sum_{i=0}^{\infty} \beta^i \Lambda_{t,t+i} \big[& P_{mt+i} Y_{t+i} + Q_{t+i} \left(1 - \delta(U_{t+i})\right) \xi_{t+i} K_{t-1+i} \\ & - Q_{t+i-1} R_{kt+i} K_{t-1+i} - \left(1 + \tau_t^{ssf}\right) W_{t+i} L_{t+i} \big] \Bigg\} \end{aligned} \tag{7}$$

with $\Lambda_{t,t+i}$ being the stochastic discount factor, P_{mt} the price of intermediate goods output, R_{kt+i} the gross interest rate, W_t the real wage and τ_t^{ssf} the social security contributions by the employer. Taking the respective derivatives yields the following optimality conditions:

Optimal Capacity Utilization:

$$\alpha P_{mt} \frac{Y_t}{U_t} = \delta'(U_t) \xi_t K_t \tag{8}$$

Optimal Labor Demand:

$$W_t = P_{mt} \left(1 - \alpha\right) \frac{Y_{mt}}{(1 + \tau_t^{ssf}) L_t} \tag{9}$$

Return to Capital:

$$E_t\{R_{kt+1}\} = \frac{E_t \left\{ P_{mt+1} \alpha \frac{Y_{t+1}}{K_t} + \xi_{t+1} Q_{t+1} (1 - \delta\left(U_{t+1}\right)) \right\}}{Q_t}. \tag{10}$$

Equation (8) represents the optimality condition for the utilization rate U_t, whereas expression (9) shows that firms pay out the marginal product of labor as wages. Finally, in equation (10) the rate of return R_{kt+1}, which the intermediate goods producing firm pays out to financial intermediaries, is pinned down.

2.2.2 Capital Producing Firms

Capital producing firms buy capital from intermediate goods producing firms and repair depreciated capital and build new one. They face flow adjustment costs regarding the production of new capital. These adjustment costs can be interpreted as kind of installation costs. Recently accumulated capital cannot be used immediately without any costs. So the higher the difference between the capital stock in $t+1$ and t, the greater will be the costs for using the new amount of capital. The costs obviously depend on net investments. Capital producing firms therefore maximize the expected, discounted profit function with respect to I_{nt}

$$\max_{I_{nt}} E_t \left\{ \sum_{i=0}^{\infty} \beta^i \Lambda_{t,t+i} \left[(Q_{t+i} - 1) I_{nt+i} - f\left(\frac{I_{nt+i} + I_{ss}}{I_{nt+i-1} + I_{ss}} \right) (I_{nt+i} + I_{ss}) \right] \right\} \tag{11}$$

with $\Lambda_{t,t+i}$ being the stochastic discount factor, I_{nt} the net investment which evolves according to $I_{nt} = I_t - \delta(U_t)\xi_t K_t$, I_{ss} the steady state investment level, and $f(\cdot)$ the convex adjustment cost function with $f(1) = f'(1) = 0$ and $f'' > 0$.
By maximizing this expression we solve for the optimal level of net investment and hence for the price Q_t of a unit of capital. Hence, Q_t is given by

$$Q_t = 1 + f(\cdot) + f'(\cdot)(I_{nt} + I_{ss}) - E_t \beta \Lambda_{t,t+1} f'(\cdot) (I_{nt+1} + I_{ss}). \tag{12}$$

This expression pins down the price of a unit of capital.

2.2.3 Retailers

Retailers are defined on an unit interval, that is, there exists a continuum of retail firms with mass unity. They buy intermediate goods producers' output and simply repackage it. So every retailer f "produces" an output Y_{ft}. It is assumed that the only marginal cost they face is the price P_{mt} which they have to pay for the intermediate good. Additionally, nominal rigidities are introduced in a Calvo fashion (see Calvo (1983)). This means, every period a firm is able to adjust its price with probability $(1-\gamma)$. If a retailer is not allowed to set its optimal price, it can index its price to lagged inflation. Hence, the price in $t+1$ evolves according to the following rule:

$$P_{t+1} = \begin{cases} P^*_{t+1}, & \text{with probability } (1-\gamma) \\ P_t(1+\pi_{t-1}), & \text{with probability } \gamma. \end{cases} \tag{13}$$

with P^*_{t+i} being the optimal price choice in period $t+i,\ \forall i \geq 0$.
By making use of the Calvo price setting mechanism in (13), we will get the following maximization problem of the retailer which is given by

$$\max_{Y_{ft}, P^*_t} E_t \left\{ \sum_{i=0}^{\infty} (\gamma\beta)^i \Lambda_{t,t+i} \left[\frac{P^*_t}{P_{t+i}} \prod_{k=1}^{i} (1+\pi_{t+k-1})^{\gamma_p} - P_{mt+i} \right] Y_{ft+i} \right\}. \tag{14}$$

This yields the subsequent first order condition

$$\sum_{i=0}^{\infty} (\gamma\beta)^i \left[\Lambda_{t,t+i} Y_{ft+i} \left[\frac{P^*_t}{P_{t+i}} \left(\frac{P_{t+i-1}}{P_{t-1}} \right)^{\gamma_p} - \mu P_{mt+i} \right] \right] = 0 \tag{15}$$

with $\mu = \frac{\varepsilon}{\varepsilon-1}$ being the frictionless markup firms set. Further, we use of the price definition $P_t = \left(\int_0^1 P_{ft}^{1-\varepsilon} \mathrm{d}f \right)^{\frac{1}{1-\varepsilon}}$ and therefore arrive at an overall aggregate price level evolution which is given by

$$P_t = \left[\gamma \Pi^{\gamma_p}_{t-1} P^{1-\varepsilon}_{t-1} + (1-\gamma) \left(P^*_t \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}. \tag{16}$$

2.3 Financial Intermediaries

Following in Gertler and Karadi (2011) and in an extended version in Kirchner (2012), we introduce financial intermediaries. Financial intermediaries are banks owned and managed by household members. They lend funds D_t obtained from households to non-financial firms. They can invest their funds in both claims S_t on non-financial firms, which are worth Q_t, and in government bonds B_t. The difference between assets and liabilities in point t is equal to the wealth N_t of the financial intermediary. Hence, the balance sheet of a bank is given by

$$P_t = Q_t S_t + B_t = N_t + D_t \tag{17}$$

with S_t being claims on intermediate goods firms with a price Q_t, B_t being investments in government bonds, D_t being deposits obtained from households and N_t the intermediaries' net worth.
The financial intermediary has to pay the non-contingent gross real interest rate R_{dt+1}

on D_t at $t+1$. Meanwhile, it earns the stochastic real return R_{kt+1} on its claims on non-financial firms and a return R_{bt+1} on government bonds. Its wealth in $t+1$ therefore evolves like:

$$N_{t+1} = R_{kt+1} Q_t S_t + R_{bt+1} B_t - R_{dt+1} D_t \tag{18}$$

We further define return R_{pt+1} as the weighted return on claims on non-financial firms and government bonds, i.e.

$$R_{pt+1} = w_t R_{kt+1} + (1 - w_t) R_{bt+1} \tag{19}$$

with w_t being the share of assets that are invested in non-financial firms. Having calculated this, we can pin down the intermediaries' objective function as it maximizes the expected wealth V_t which is equivalent to the sum of future net worth until the banker has to exit the market. This is given by

$$V_t = \max E_t \left\{ \sum_{i=0} (1-\theta)\, \theta^i \beta^i \Lambda_{t,t+1+i} \left(N_{t+1+i} \right) \right\}.$$

with β being the subjective discount factor, and $\Lambda_{t,t+i}$ the stochastic discount factor the banker applies to earnings in $t+i$.
The intermediary maximizes this objective function subject to the constraint

$$E_t\{\beta \Lambda_{t,t+1+i} \left(R_{pt+1+i} - R_{dt+1+i} \right)\} \geq 0, \qquad i \geq 0. \tag{20}$$

This means that the return on assets in every period must be at least as high as the expenditures on the liabilites. Note that in perfect capital markets equation (20) holds with equality, but does not necessarily hold in the case of imperfect capital markets. Since our model does not feature an arbitrage assumption, equation (20) may take positive values period by period. If this is the case, the intermediary has an incentive to infinitely increase the amount of assets which can only be done by borrowing infinitely from households. Because we do not see such a behaviour in reality, we impose a lending constraint on the intermediary. For this we introduce the following mechanism: An intermediary can divert a fraction λ of overall assets from the project to the household. Remember that the household also owns the financial intermediary. On the one hand, transferring money from the financial intermediary to the household decreases the profit of the bank, but on the other hand increases household's income. Hence, the banker gains. However, having diverted the fraction λ of overall assets leads to the fact that

only the fraction $1-\lambda$ of assets remains. This is the amount of assets investors can recover once the banker went bankrupt. Investors are therefore only willing to lend to the intermediary when they can expect to receive their funds back. This is the case if the intermediary does not divert funds or at least limits the amount of funds which he/she diverts from the project to the household.
However, what is the gain of diverting funds? The intermediary can gain the amount λP_t when diverting λ. At the same time, the amount of assets would decrese to $(1-\lambda)$. Investors, therefore, only continue to lend if they know that the gain of diverting the fraction λ and gaining the value of these fraction P_t is smaller than the money the intermediary can earn when letting the amount of assets invested on capital markets. This can be formally pinned down as

$$\underbrace{V_t}_{loss} \geq \underbrace{\lambda(Q_t S_t + B_t)}_{gain}. \tag{21}$$

with V_t being, loosely speaking, opportunity costs of having diverted the fraction λ of assets. We assume the value function V_t to be of the form

$$V_t = \nu_{kt} Q_t S_t + \nu_{bt} B_t + \eta_t N_t. \tag{22}$$

with ν_{kt} being the marginal gain of expanding $Q_t S_t$ by one unit holding everything else constant, ν_{bt} being the marginal gain of expanding B_t by one unit holding everything else constant, and η the marginal gain of having another unity of N_t. We can solve for the marginal values by writing down the Bellman equation for this problem. We then get

Marginal Value of Banks' Capital Assets:

$$\nu_{kt} = \beta E_t \Lambda_{t,t+1} \left[(1-\theta)(R_{kt+1} - R_{dt+1}) + \theta \nu_{kt+1} x_{kt+1}\right] \tag{23}$$

Marginal Value of Banks' Bond Assets:

$$\nu_{bt} = \beta E_t \Lambda_{t,t+1} \left[(1-\theta)(R_{bt+1} - R_{dt+1}) + \theta \nu_{bt+1} x_{bt+1}\right] \tag{24}$$

Marginal Value of Banks' Net Wealth:

$$\eta_t = \beta E_t \Lambda_{t,t+1} \left[(1-\theta) R_{dt+1} + \theta \eta_{t+1} z_{t,t+1}\right] \tag{25}$$

with $(R_{kt+1} - R_{dt+1})$ being the risk premium between the return on non-financial firms and the payment on liabilities, $(R_{kt+1} - R_{bt+1})$ being the risk premium between the return on government bonds and the payment on liabilities, $x_{kt,t+1}$ the gross growth rate of investments in non-financial firms between t and $t+1$, generally given by $x_{t,t+i} = \frac{Q_{t+i}S_{t+i}}{Q_tS_t}$, $x_{bt,t+1}$ the gross growth rate of investments in government bonds between t and $t+1$, generally given by $x_{t,t+1} = \frac{B_{t+1}}{B_t}$, and $z_{t,t+1}$ the gross growth rate of net worth, generally given by $z_{t,t+i} = \frac{N_{t+i}}{N_t}$.

Further, the financial intermediary maximizes the value function (22) subject to the incentive constraint (21) which holds with equality in equilbrium. This results to ν_{kt} being equal to ν_{bt} which, in turn, implies that

$$\nu_{kt}\left(Q_tS_t + B_t\right) + \eta_tN_t = \lambda\left(Q_tS_t + B_t\right) \tag{26}$$

$$\Leftrightarrow P_t = \phi_tN_t \tag{27}$$

with $\phi_t = \frac{\eta_t}{\lambda - \nu_{kt}}$ being the ratio of privately intermediated assets with $0 < \nu_t < \lambda$. This result shows that financial intermediaries are endogenously capital constrained. As long as we impose the incentive constraint on the willingness of investors to lend to bankers, bankers can not infinitely and easily increase their assets.

We are now able to derive expressions for the gross growth rate of equity or net worth $z_{t,t+1}$ and the gross growth rates in assets $x_{kt,t+1}$ as well as $x_{bt,t+1}$. We know that N_{t+1} evolves as $N_{t+1} = R_{kt+1}Q_tS_t + R_{bt+1}B_t - R_{dt+1}D_t$. By plugging in the balance sheet constraint in order to cancel out D_t and by assuming that the return on investments on non-financial firms is equal to the return on government bonds, i.e. $R_{kt+1} = R_{bt+1}$, we arrive at

$$N_{t+1} = \left(R_{kt+1} - R_{dt+1}\right)P_t + R_{dt+1}N_t. \tag{28}$$

Using expression (27) and dividing the whole equation by N_t yields

$$z_{t,t+1} = \left(R_{kt+1} - R_{dt+1}\right)\phi_t + R_{dt+1}. \tag{29}$$

To derive the gross growth rate for capital assets $x_{kt,t+1}$, we can simply use the fact that only a share of overall assets is invested in claims on non-financial firms, i.e. $x_{kt,t+1} = \frac{Q_{t+1}S_{t+1}}{Q_tS_t} = \frac{w_{t+1}P_{t+1}}{w_tP_t}$. Using this yields the gross growth rate for capital assets

$$x_{kt,t+1} = \frac{(1 - w_{t+1})\phi_{t+1}}{(1 - w_t)\phi_t} z_{t,t+1} \tag{30}$$

and the gross growth rate of government bond investments

$$x_{bt,t+1} = \frac{w_{t+1}\phi_{t+1}}{w_t\phi_t} z_{t,t+1}. \tag{31}$$

As we mentioned before and what will also be simulated later on, the financial crisis featured a sharp decline in asset values. Given a certain liability structure, this affects intermediaries' net worth N_t. We therefore need to formulate a law of motion for net worth, where we first take into account that every period bankers stay banker with probability θ, whereas some have to exit the market with probability $(1-\theta)$. As a result, overall net worth is the sum of the net worth of new bankers N_{nt} and existing bankers N_{et}. It follows

$$N_t = N_{et} + N_{nt}. \tag{32}$$

Having in mind that only a fraction θ survives from $t-1$ to t, existing banker's net wealth in t evolves according to

$$N_{et} = \theta \left[\left(R_{kt} - R_t \right) \phi_{t-1} + R_t \right] N_{t-1}. \tag{33}$$

New bankers receive start up funds from their respective households. Since financial intermediaries are owned by households, household members essentially transfer a certain fraction of funds to financial intermediaries. The amount they are willing to transfer is pinned down by the amount existing bankers have intermediated. That is households observe the former level of intermediated assets and then decide how much to provide. We know that the total amount of intermediated assets in t of bankers that have to leave the market is equal to P_t, keeping in mind that only a fraction $1-\theta$ has to exit. Households are now willing to supply the share $\frac{\omega}{1-\theta}$ to new bankers which results in a net wealth of entering bankers given by

$$N_{nt} = \frac{\omega}{(1-\theta)} \left(1-\theta\right) P_t = \omega P_t. \tag{34}$$

2.4 Monetary Authority

As presented before, financial intermediaries are endogenously capital constrained. This means that their demand for assets directly depends on their net wealth or equity respectively. In times of a crisis, their asset values as well as their net wealth can deteriorate sharply and hence governmental or rather monetary authority support can be crisis impact weakening. The monetary authority can facilitate lending, i.e. providing funds to financial intermediaries. The monetary authority does so by issuing debt to financial intermediaries. Financial intermediaries, in turn, obtain the funds, which are needed to buy the government bonds, from households. The monetary authority lends the funds at the market lending rate R_{kt+1}. Note that in contrast to private banks, the monetary authority faces efficiency costs τ. These can be seen as costs of finding optimal investment strategies or just costs of intermediating assets. Additionally, the monetary authority is not endogenously capital constrained since it can, unlike private intermediaries, borrow infinitely. If we allow for the possibility that the monetary authority can provide a certain fraction of funds, we can rewrite equation (17) according to

$$P_t = P_{pt} + P_{gt} \tag{35}$$

with P_{pt} being the amount of privately intermediated assets and P_{gt} the amount of assets intermediated via government assistance.
The monetary authority is now willing to fund a certain fraction ψ_t of overall assets

$$P_{gt} = \psi_t P_t \tag{36}$$

with ψ_t being the fraction of publicly intermediated assets with $0 < \psi_t < 1$.
Combining now equation (27), (36) and plugging them in expression (35) yields

$$\begin{aligned} P_t &= \phi_t N_t + \psi_t P_t \\ P_t &= \phi_{ct} N_t. \end{aligned} \tag{37}$$

with $\phi_{ct} = \frac{\phi_t}{1-\psi_t}$ being the leverage ratio of total, i.e. privately as well as publicly, intermediated assets. It can be easily seen that the demand for assets positively depends on ψ_t. The higher ψ_t, the higher the leverage ratio and hence the higher the amount of assets.

The feedback rule according to which the central bank provides funds in times of a crisis is given by

$$\psi_t = \psi + \nu \left[(R_{kt+1} - R_{dt+1}) - (R_k - R) \right] \tag{38}$$

with ν being the feedback parameter, $(R_{kt+1} - R_{dt+1})$ the current risk premium, and $(R_k - R_d)$ the steady state risk premium. This feedback rule illustrates that the monetary authority jumps in if the spread between the capital market gross interest rate R_{kt+1} and the risk free gross interest rate R_{dt+1} increases. This spread increases in times of a crisis and therefore also the fraction of assets that the monetary authority supplies, indicated by a higher ψ_t.

Monetary policy is conducted via a simple Taylor rule given by

$$i_t = \left(R_d \pi_t^{\kappa_\pi} \tilde{y_t}^{\kappa_y}\right)^{1-\rho} i_{t-1}^{\rho} \varepsilon_t^i \tag{39}$$

with i_t being the nominal interest rate, R_d the steady state nominal interest rate, ρ the interest rate smoothing parameter with $0 < \rho < 1$, $\tilde{y}_t$ the log-deviation of actual output from its flexible price equilibrium level, and ε_t an exogenous shock to monetary policy with $\varepsilon_t \; N(0, \sigma_i^2)$. The relation between the gross real return on deposits, the gross nominal return on deposits and inflation is described by the Fisher rule

$$(1 + i_t) = R_{dt} E_t\{1 + \pi_{t+1}\}. \tag{40}$$

2.5 Government Budget Constraint and Fiscal Rules

A significant drawback of Gertler and Karadi (2011) and their financial accelerator framework was the little importance of the government. We overcome this drawback by introducing distortionary taxes and by expanding the fiscal sector.

The government finances its expenditures by raising taxes on consumption and labor with different tax rates. It consumes the public good G_t, issues Bonds B_t, makes lump-sum transfers to households TR_t, and, in times of a crisis, can provide funds S_{gt} to financial intermediaries. Hence, the budget constraint is given by

$$T_t + B_t + (R_{kt} - R_{bt})\, S_{gt-1} = G_t + R_{bt} B_{t-1} + \tau S_{gt} + TR_t.$$

Government's tax income is as follows

$$T_t = \tau_t^c C_t + \left(\tau_t^l + \tau_t^{ssh} + \tau_t^{ssf}\right) W_t L_t$$

with τ_t^c being the consumption tax rate, τ_t^l being the labor tax rate and τ_t^{ssh} and τ_t^{ssf} the social security contributions by households and firms respectively. The fiscal instruments are assumed to follow simple feedback rules like proposed in Coenen, Straub, Trabandt (2013). Hence, taking consumption tax rate as an example, the fiscal rule is given by

$$\tau_t^c = {\tau_{t-1}^c}^{\rho_c} \left[\tau_{ss}^c \left(\frac{Y_t}{Y_{ss}}\right)^{\theta_{cy}} \left(\frac{B_t}{B_{ss}}\right)^{\theta_{cb}}\right]^{1-\rho_c} \epsilon_t^c.$$

Tax rates react to their own lagged values as well as to output and government debt.

2.6 Resource Constraints

We close the model by defining overall resource constraints for the economy. So firstly, overall output is composed of consumption, investment, government consumption, adjustment costs due to investments, and costs for monetary authority intervention on capital markets. Formally:

$$Y_t = C_t + I_t + G_t + f\left(\frac{I_{nt} + I_{ss}}{I_{nt-1} + I_{ss}}\right)(I_{nt} + I_{ss}) + \tau\psi_t P_t \tag{41}$$

with Y_t being output, C_t consumption, I_t investment, G_t government expenditures, $f\left(\frac{I_{nt}+I_{ss}}{I_{nt-1}+I_{ss}}\right)(I_{nt}+I_{ss})$ adjustment costs due to net investments, and $\tau\psi_t P_t$ expenditures that arise because the government provides funds to financial intermediaries.
Further, capital evolves according to the following expression

$$K_{t+1} = \xi_t K_t + I_{nt}. \tag{42}$$

This completes the description of the model.

3 Data

The model is calibrated and estimated for the Euro Zone. For this purpose, we use quarterly time series for selected macroeconomic variables in the Euro zone. These observables are real GDP, real private consumption, real government consumption, total employment, inflation, and real wages per head. Data is taken from an updated version of the Area Wide Model (AWM) database which covers the years 1980 until 2011. Further, in line with Coenen, Straub, and Trabandt (2013), we exploit a new fiscal database by Paredes, Pedregal, and Perez (2009). This dataset provides data on consumption and labor tax rates, social security contributions from firms and households, lump-sum transfers to households and aggregated government debt.

Since all macroeconomic aggregates except the tax rates are non-stationary, we use the first log-difference minus the average growth rate in order to match the data to the model. From social security contributions, tax rates and transfers we substract HP-trends.

As we use twelve observables, we need at least twelve shocks to have enough degrees of freedom. The shocks affect households' preferences regarding consumption and labor supply, productivity, the interest rate, the net wealth of banks, capital quality, government spending, credit policy, and the fiscal policy variables. All shocks except the fiscal policy variables shocks follow autoregressive processes of order one. These parameters are also estimated.

4 Calibration and Estimation

The model is estimated with Bayesian techniques. In order to estimate posterior distributions of selected parameters, we assume prior distributions for parameters and use observables to update these distributions.

Formally, let $p\,(\Omega|\, m)$ be the prior distribution of a parameter vector Ω for some model m, and let $\mathscr{L}(Y_t|\,\Omega, m)$ be the likelihood function for the observed data conditional on parameter vector Ω and model m, then the posterior distribution is obtained by the product of the prior distribution and the likelihood function:[1]

$$p(\Omega|\, Y_t, m) \propto \mathscr{L}(Y_t|\,\Omega, m) p\,(\Omega|\, m)\,. \tag{43}$$

This relation holds with proportionality. We eventually obtain the mode and the standard deviation for the posterior distribution and confidence intervals for the estimated parameters.

4.1 Calibration

In Table 1 we calibrate key parameters. Since some model parameters as for instance the subjective discount factor β are fairly standard in the DSGE literature, we calibrate them as in Gertler and Karadi (2011). For the time being, we also calibrate the three financial parameters, namely the fraction of capital that can be diverted λ, the proportional transfer to entering bankers ω and the survival probability θ, as in Gertler and Karadi (2011). There are two reasons. Firstly, these parameters are hard to identify empirically and, secondly, by choosing the same parameter values we are able to compare the results of both models. Specific to our model are the fiscal policy parameters. Here, we calibrate the steady state tax rates on consumption, labor and social security security contributions as the average between 1980 and 2011.

[1]See Christoffel, Coenen, and Warne (2008) for a short and An and Schorfheide (2007) for a detailed description

Table 1: Calibration of key steady-state ratios and selected parameters

Share / parameter	Description	Value
Households		
β	Discount factor	0.99
h	Habit parameter	0.815
χ	Relative utility weight of labor	3.409
φ	Inverse Frisch elasticity of labor supply	0.276
Firms		
α	Capital share in production	0.33
ζ	Elasticity of marginal depreciation w.r.t. utilization rate	7.2
η_i	Inverse elasticity of net investment to the price of capital	1.728
ϵ	Elasticity of substitution	4.167
γ	Probability of price change	0.779
γ_p	Price indexation parameter	0.241
Financial Intermediaries		
λ	Fraction of capital that can be diverted	0.381
ω	Proportional transfer to entering bankers	0.002
θ	Survival rate of bankers	0.972
ϕ	Steady state leverage ratio	4
$R_k - R_b$	Quarterly interest rate spread	0.0025
Monetary and Fiscal Authority		
$\frac{G}{Y}$	Proportion of government expenditures	0.2
$\frac{B}{Y}$	Debt-to-output ratio	0.6
υ	Unconventional monetary policy parameter	$[0, 10, 100]$
τ_t^c	Consumption tax rate	0.2162
τ_t^l	Labor income tax rate	0.2347
τ_t^{ssh}	Employees' social security contribution tax rate	0.1578
τ_t^{ssf}	Employers' social security contribution tax rate	0.165

Notes: Values are based on Gertler, Karadi (2011). Tax rates, however, are calculated with data from the fiscal database and reflect average tax rates from 1980 to 2011.

4.2 Priors

We estimate the fiscal policy parameters as well as the Taylor Rule parameters. We assume the same prior distributions for the fiscal parameters as Coenen, Straub, and Trabandt (2013). This means all feedback parameters for output and debt are assumed to follow a normal distribution with mean zero and standard deviation two. The autoregressive parameters follow beta distributions with mean 0.5 and standard deviation two. The Taylor rule parameters' prior distributions are set as in Smets and Wouters (2007). We then estimate all parameters with Bayesian techniques and obtain the posterior distributions. The results are presented in Table 2.

Table 2: Estimated Parameters - Priors and Posteriors

Parameter	Prior distribution	Posterior distribution Mode	Mean	5%	95%
Output feedback coefficients in fiscal rules					
θ_{cy}	$N(0,2)$	-0.7549	-0.7429	-0.9558	-0.5369
θ_{ly}	$N(0,2)$	0.3324	-0.2422	0.1572	0.3495
θ_{sshy}	$N(0,2)$	-0.1885	-0.0977	-0.2638	0.0392
θ_{ssfy}	$N(0,2)$	0.0534	0.0230	-0.2159	0.2476
θ_{try}	$N(0,2)$	0.2218	0.1015	0.0009	0.2298
θ_{gy}	$N(0,2)$	0.9809	0.9923	0.7424	1.2030
Debt feedback coefficients in fiscal rules					
θ_{cb}	$N(0,2)$	0.2486	0.2492	0.1385	0.3692
θ_{lb}	$N(0,2)$	0.0386	0.0661	0.0046	0.1245
θ_{sshb}	$N(0,2)$	-0.1833	-0.3181	-0.4898	-0.1405
θ_{ssfb}	$N(0,2)$	0.0636	0.0650	-0.0222	0.1550
θ_{trb}	$N(0,2)$	0.2645	0.3229	0.1378	0.4788
θ_{gb}	$N(0,2)$	-0.1730	-0.2193	-0.3664	-0.0765
Lagged dependent variable in fiscal rules					
ρ_c	$B(0.5,0.2)$	0.9078	0.9044	0.8976	0.9102
ρ_l	$B(0.5,0.2)$	0.8026	0.7860	0.7860	0.8074
ρ_{ssh}	$B(0.5,0.2)$	0.9561	0.9586	0.9428	0.9722
ρ_{ssf}	$B(0.5,0.2)$	0.9064	0.9041	0.9002	0.9079
ρ_{tr}	$B(0.5,0.2)$	0.9348	0.9357	0.9346	0.9371
ρ_g	$B(0.5,0.2)$	0.9610	0.9614	0.9602	0.9624
ρ_{tax}	$B(0.5,0.2)$	0.8263	0.8235	0.8101	0.8387
Taylor Rule parameters					
κ_π	$N(0,2)$	1.6564	1.6477	1.6294	1.6601
κ_y	$N(0,2)$	0.0227	0.0240	0.0213	0.0270

Notes: The posterior distribution is obtained using the Metropolis-Hastings algorithm.
Source: Own calculations, Coenen, Straub, and Trabandt (2013), Smets and Wouters (2007)

First, Table 2 shows that there is in general little response of fiscal variables to changes in output and debt. When we have a closer look at the feedback coefficients regarding debt, we see that debt does not seem to be an important indicator for fiscal policy. In turn, especially the transfer and government consumption parameters θ_{try} and θ_{gy} show high reaction to changes in output, whereas tax rates do not seem to be influenced by output changes. These findings are in line with those of Coenen, Straub, and Trabandt (2013). We will make use of these estimates in the subsequent sections.

5 Results

In this section we study the deterioration of asset values which is simulated with a negative shock to the quality of capital. We analyze three different policy instruments that can be implemented as a reaction to the shock. These are unconventional monetary policy by the central bank, fiscal policy by the government and the combination of both.

5.1 Crisis Experiment I

Figure 1 presents the impulse response analysis of the first crisis experiment. Here we investigate the same experiment as in Gertler and Karadi (2011). We negatively shock the quality of capital by 5% and compare our results to the ones presented in Gertler and Karadi (2011). Results are shown below.

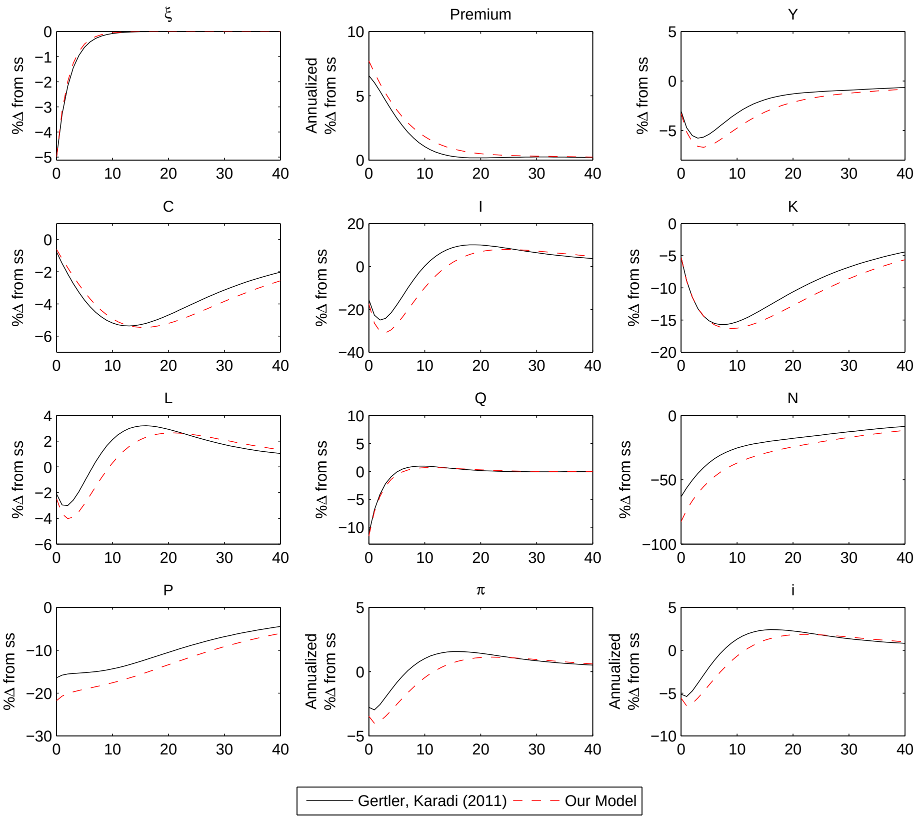

Figure 1: Responses to a Capital Quality Shock[2]

The solid, black line represents the results reported by Gertler and Karadi (2011), whereas the red, dashed line portrays our results. We see that our results are well in line with the ones from Gertler and Karadi (2011), however, the extended version accelerates the negative effect of a capital quality shock. The mechanism is as follows. The capital quality shock decreases the effective amount of capital. This has two effects. First, there is less capital which can be used for production (the capital stock drops by about 15%). Second, since financial intermediaries are invested in both government

[2]Source: Own calculations

bonds and, importantly, in the capital stock of firms, asset deterioration takes place. As a result, the risk premium increases substantially and investment costs rise which, in turn, leads to less investment. Altogether, this yields a drop in output of 5.7% in the case of Gertler and Karadi (2011) and 6.7% in our case. Apparently, the incorporation of distortionary taxes and a portfolio choice for financial intermediaries exacerbates the effect of a 5% capital quality shock.

5.2 Crisis Experiment II

From now on, we focus on our results. Here we investigate the case of unconventional monetary policy intervention. We set the central bank's feedback parameter υ to 0, 10 or 100. A value of zero reflects no intervention at all, whereas a value of 10 reflects moderate unconventional intervention and 100 aggressive unconventional intervention, respectively. Higher values for υ indicate that the central bank is more sensitive to changes in the risk premium.

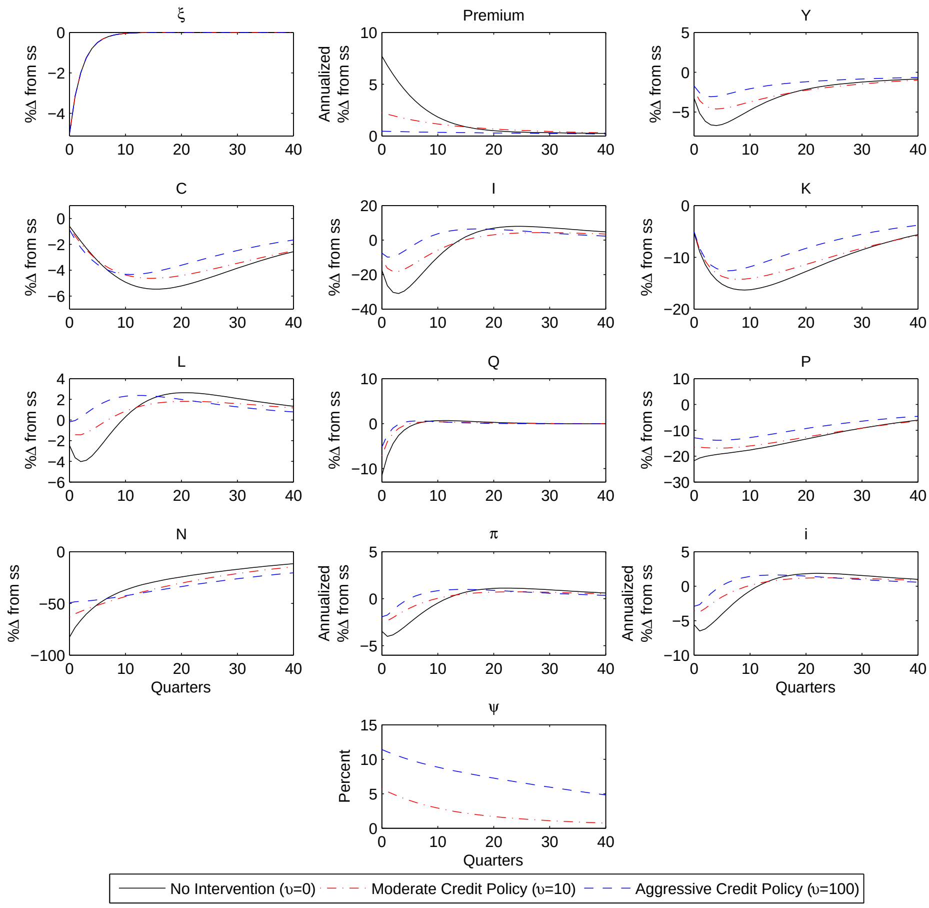

Figure 2: Credit Policy as a Response to a Capital Quality Shock[3]

Here, the solid, black line represents the case without credit policy in my setup. The red, dashed and dotted line portrays the case with baseline credit market intervention ($\upsilon = 10$) and the blue, dashed line the aggressive behaviour ($\upsilon = 100$) of the central bank. Importantly, the feedback parameters of the fiscal policy rules are all set to zero, which means there is no fiscal adjustment. We see that output drops severely due to a capital quality shock, but credit market intervention dampens the contraction significantly. This is due to the fact that credit policy is able to successively reduce the spread in the premium. Whereas the spread increases by 8.3% due to the capital shock without intervention, it does only increase by 2.5% in the baseline credit policy case and 0.5% in the aggressive case respectively. This reduction is bought by an increase in central banks balance sheet equal to 6.2% (see last graph). This value even increases to 12.6% in the aggressive case. The central bank therefore provides considerable amounts of funds to financial intermediaries. This intervention succeeds since it leads to a reduction in the spread and hence to a lesser decline in investment and output. Noteworthy is the fact the downturn in output is even higher in this framework than in Gertler and Karadi (2011). The incorporation of distortionary taxes and portfolio choice for banks seems to have even more severe economic effects.

5.3 Crisis Experiment III

Now we investigate the event that the government uses its fiscal policy tools in times of a crisis to combat a recession. In Section 4 we estimated the feedback as well as the autoregressive parameters of the fiscal policy rules. Here, we first of all assume that the central bank does not jump in in times of a crisis, but the government may adjust its tax rates or transfers according to the estimated values from the Euro Zone. The results are presented subsequently in Figure 3.

The solid, black line represents the case without any fiscal policy adjustments, i.e. the case where the economy is purely hit by the capital quality shock. The red, dashed and dotted line illustrates the case with fiscal parameters' adjustment according to the estimates from Table 2. We see that when the government reacts to changes in debt and output and adjusts its fiscal parameters, the downturn is less significant. Output, for instance, decreases by only 5.3% in comparison to 6.7% in the baseline case without any intervention. Government intervention succesfully reduces the recession. The reason is that the asset position and the net wealth of financial intermediaries does not decrease as much as in the case without fiscal adjustments. Hence, the asset value deterioration is less severe, which, in turn, lets investment and output drop less significantly.

Furthermore, the last four impulse responses show the cyclical behaviour of the fiscal parameters. We see that after the shock the consumption tax rate, the labor tax rate and

[3] Source: Own calculations

the social security contributions by employers decrease and and do not converge back to their original levels, not even after 40 quarters. The social security contributions by employees, in turn, increases and also does not reach its pre-crisis level after 40 quarters. However, we see that tax rate adjustment is quite small in response to a shock, with is well in line with economic theory about tax rate smoothing.

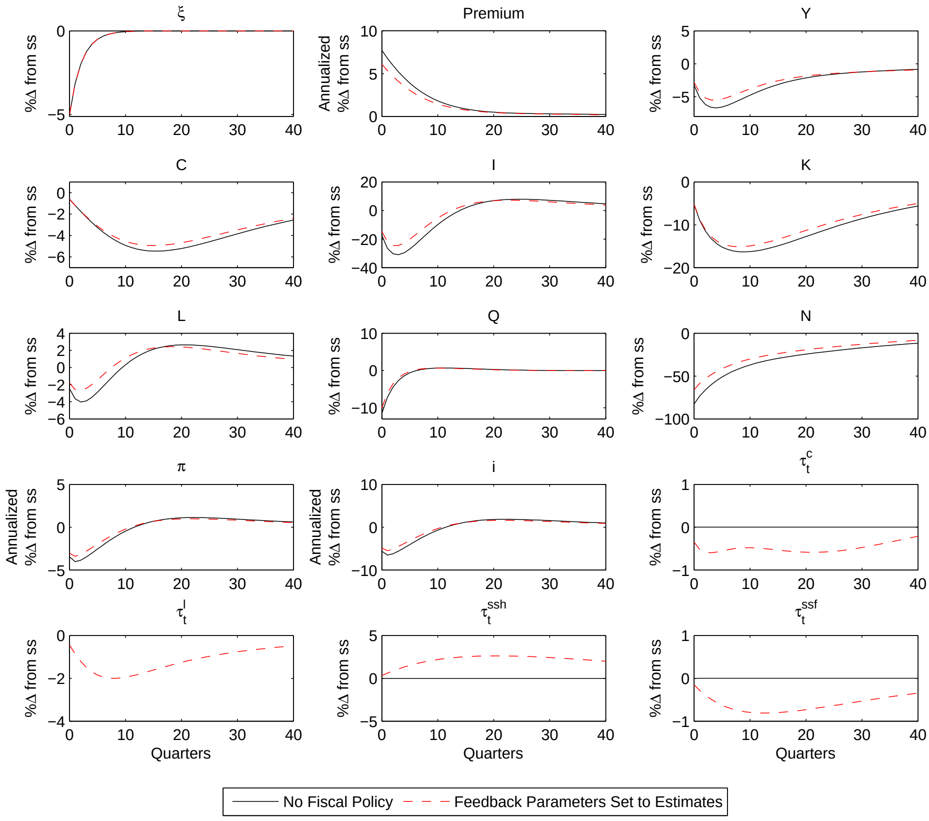

Figure 3: Government Intervention in Response to a Capital Quality Shock[4]

5.4 Crisis Experiment IV

As a last experiment, we investigate the combination of both policy tools, that is credit policy intervention and fiscal parameter adjustment. Figure 4 presents the results. The combination of both tools, that is providing funds to financial intermediaries and the adjustment of fiscal parameters in times of a crisis, has the most recession easing effect. If both tools are combined, output drops by not even 4% which is almost 3% lower than without any intervention and another 1.5% less than with just feedback adjustment, but without credit policy.

[4]Source: Own calculations

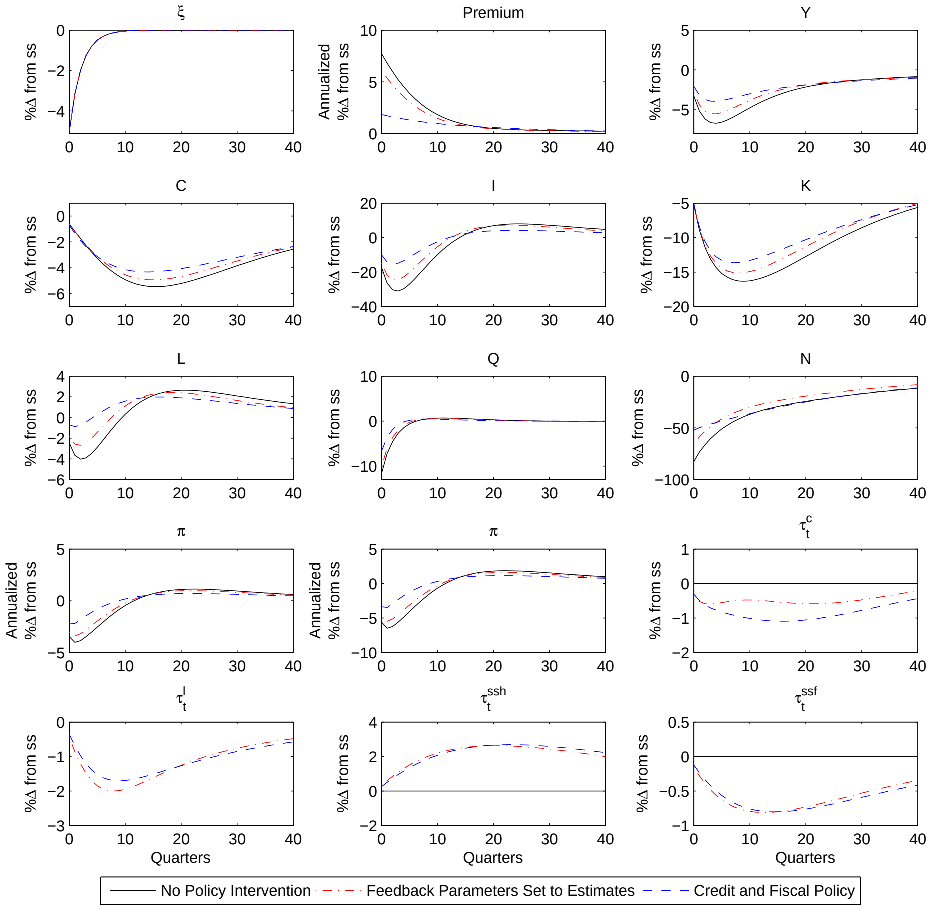

Figure 4: Credit Policy and Government Intervention in Response to a Capital Quality Shock[5]

6 Conclusion

In this paper we develop and estimate a model to identify the impact of credit policy as well as fiscal policy. To do so, we used a Dynamic Stochastic General Equilibrium Model with financial frictions and an extended fiscal sector. With data from the Euro Zone we estimated monetary and fiscal parameters. We find that, in line with Gertler and Karadi (2011), the financial accelerator model well replicates the output deterioration of about 6.7% due to a capital quality shock during the financial crisis. As we present in 1, the incorporation of distortionary taxes and portfolio choice for banks leads to a more severe recession than in Gertler and Karadi (2011). Further, in the second case, in order to combat the recession, the central bank conducts unconventional monetary policy, while the fiscal authority does not adjust fiscal parameters such as tax rates and

[5]Source: Own calculations

expenditures. This policy leads to a less significant drop in output of about 4.6% in the moderate case. When the central bank jumps in aggressively, output deterioration is only 3.1%. We also estimate feedback rule parameters with data for the Euro zone. Results show that fiscal policy only slightly reacts to changes in debt and output and that fiscal parameters are highly autoregressive. Incorporating fiscal policy adjustment results in less significant output drops. Eventually, in the last case, we investigate the combination of both instruments. We see that unconventional monetary policy and fiscal policy has the most significant recession easing effect.

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