Fiscal Policy with Credit Constrained Households

by

Werner Roeger and Jan in 't Veld

European Commission,
DG ECFIN - Economic and Financial Affairs,
Brussels

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Abstract:

The current financial crisis is characterised by an increase in credit constraints and risks of deflation. This situation has revived the discussion about the role of fiscal policy. This paper explores the effects of credit constraints on the effectiveness of fiscal policy in a DSGE model with housing investment and credit constrained households. We show that the presence of credit constrained households raises the marginal propensity to consume out of current net income but consumption retains a strong interest rate effect. This makes fiscal policy a more powerful tool for short run stabilisation especially in the case of deflationary shocks which likely reduces the interest rate response of the Central Bank to fiscal measures.

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1. Introduction

With the financial crisis spreading to the real economy, there has been a revival of interest in discretionary fiscal policy. As aggregate demand has plummeted, the sole reliance on the operation of automatic stabilisers has been called into question. In order to support efforts taken by central banks to stabilise the business cycle, there have been widespread calls for fiscal policy measures to prevent a sharp decline in output. The European Council approved in December 2008 a European Economic Recovery Plan, consisting of structural reforms and fiscal measures amounting to around EUR200 bn to support demand and avoid a sharp recession[1]. In response to the crisis many European countries have announced measures raising public expenditure and/or reducing taxes. In addition, the incoming U.S. administration has announced plans for a large fiscal stimulus amounting to more than $800 bn..

This revival of fiscal policy has renewed the debate about the effectiveness of short term fiscal stabilisation. A decade ago, there was widespread agreement that it was best to "let fiscal policy have its main countercyclical impact through the automatic stabilizers" and that "…discretionary fiscal policy to be saved explicitly for longer term issues, requiring less frequent changes" (Taylor, 2000,2009). It was argued that countercyclical discretionary fiscal policy was "neither desirable nor politically feasible" (Eichenbaum, 1997) and "deliberate 'countercyclical' discretionary policy has not contributed to economic stability and may have actually been destabilizing in the past" (Feldstein, 2002). These pessimistic views on the effectiveness of fiscal policy might have been justified by specific factors. First, the last decades have been characterised by a dominance of supply shocks. Blinder and Rudd (2008) provide empirical evidence on the importance of supply factors for explaining the stagflation period from the beginning of the 1970s to the mid-1980s, with two recessions in 1973-74 and 1982 heavily influenced by strong increases in oil prices. The sudden increase in oil prices associated with the first Iraq war in 1991 also contributed to the recession in the early 1990s. When the economy is hit by supply shocks there is little active discretionary fiscal policy can do. A second factor that justified the scepticism on fiscal policy was the rapid financial liberalisation. As more households acquired access to financial markets and were able to smooth their consumption, fiscal policy became less powerful.

The present situation is different with a large negative demand shock and an increase in credit constraints. This has led many economists to reconsider a possible role for discretionary fiscal policy to complement the operation of automatic stabilisers. The concern that, with interest rates at an all time low, there remains little scope for conventional monetary policy measures, has reinforced this revival of interest in fiscal policy[2]. It is generally agreed that for fiscal policy to be effective, measures have to be designed to be timely, targeted, and temporary. But it is generally feared that this crisis could be longer lasting than average past recessions. Reinhart and Rogoff (2008) document the aftermath of severe financial crises and argue that these are protracted affairs, with output falling an average over 9 percent, over a duration of roughly two years. Given the expected duration of the crisis, the often-raised criticism against discretionary fiscal policy, i.e. that it arrives too late, seems less relevant at the current juncture.

[1] The plan provides a common framework for the efforts made by Member States and by the European Union, with a view to ensuring consistency and maximising effectiveness.
[2] See e.g. Feldstein (2009), Auerbach (2009) and Spilimbergo et al. (2008).

This paper examines the effectiveness of fiscal policy in a modern dynamic stochastic general equilibrium (DGSE) model in which credit constraints play an important role. The main transmission channels of the financial crisis into the real economy are thought to be through higher risk premia and credit rationing for households and firms. By disaggregating households into credit constrained and a non-constrained group, along the lines suggested by the recent literature on the financial accelerator mechanism[3], we can examine the importance of tighter credit constraints on the effectiveness of discretionary fiscal policy. The presence of credit constrained households raises the marginal propensity to consume out of current net income and makes fiscal policy a more powerful tool for short run stabilisation. A model with credit constraints also displays a positive co-movement of consumption to government spending shocks even when allowing for labour adjustment costs (in contrast to Gali et al (2007)). A second reason why fiscal policy can be more powerful now is that with deflationary shocks like the current financial crisis monetary policy can be more accommodative towards the fiscal stimulus, and allow real interest rates to fall. Credit constrained consumers react even more strongly to a fall in real interest rates.

The rest of the paper is structured as follows. The next section starts with a brief overview of the empirical literature on the effectiveness of fiscal policy. This is followed by a review of credit constraints in the recent downturn. In section 4 we describe the model with a special emphasis on the household sector. In this section we also explore how credit constrained households respond to changes in current income and interest rates. The following section presents the simulation results and discusses the effect the introduction of credit constrained households has on the effectiveness of temporary tax and expenditure measures with and without an accommodative monetary policy. We use a two-region version of this model, consisting of the EU and the rest of the world, to look at the effects of a fiscal stimulus in the EU alone as well as a global fiscal stimulus, and also consider spillovers across the two regions. The final section concludes.

2. Overview of empirical literature

The empirical literature on the effects of discretionary fiscal policy shows estimates of fiscal multipliers vary widely. Approaches based on micro studies of past tax rebates show roughly half to two-third of the income effect is spent on higher consumption (e.g. Broda and Parker, 2008) but this contrasts sharply with macro evidence that shows no increase in consumption following the May 2008 US tax rebate (Taylor, 2009). Narrative studies of the effects of tax changes find very large effects, like a (permanent) 1 per cent of GDP tax increase leading to a 3 per cent contraction in GDP (Romer and Romer, 2007). On the other hand, narrative studies of episodes of extraordinary spending have tended to find much weaker or negative effects on output (Ramey and Shapiro, 1998).

Estimates from VAR studies also vary widely. Blanchard and Perotti (2002) applied structural vector autoregression (SVAR) methodology to study the effects of fiscal policy in the US. They find positive effects on output for increases in spending and negative effects for increases in taxes. In most cases the multipliers are small, often close to one. Gali et al. (2007) report VAR estimates for the US using data back to the 1950s and report a spending multiplier of 0.78 on impact and of 1.74 at the end of the second year. Using sign restrictions

[3] See e.g. Kiyotaki and Moore (1997) , Iacoviello (2005), Iacoviello and Neri (2008), Monacelli (2007), Calza, Monacelli and Stracca (2007).

on the impulse response functions, Mountford and Uhlig (2005) estimate the effects of a "balanced budget" and a "deficit spending" shock. They find that government spending shocks crowd out both residential and non-residential investment, but they hardly change consumption (the response of the latter is small and insignificant). Various authors have extended the SVAR methodology to include other countries. Perotti (2005) looks at five OECD countries and finds generally weaker effects when including interest rates in the VAR. The effects of government spending shocks and tax cuts on GDP and its components have become substantially weaker over time: in the post-1980 period these effects are mostly negative, in particular on private investment. Only for the US is the consumption response found positive and did the GDP multiplier exceed one in the post-1980 period. De Castro and Fernandez de Cos (2006) find a positive relationship between government spending and output in the short term for Spain, but a negative one in the medium and long term, while Giordano et al. (2007) find a positive and persistent effects on output and consumption for Italy. Afonso and Sousa (2009) investigate the macroeconomic effects of fiscal policy using a Bayesian Structural Vector Autoregression approach on quarterly date for four countries and stress the importance of explicitly modelling government debt dynamics in the model. They find government spending shocks have in general a small effect on GDP, often negative, and lead to important crowding-out effects, in particular on investment.

Estimates from DSGE models also differ widely with respect to the effectiveness of fiscal policy. While there seems to be agreement that there is a crowding out effect of government spending on private investment, there is little consensus on the effect of government spending on private consumption both empirically and in the DSGE literature. A positive consumption multiplier is a prerequisite for a large expenditure multiplier. Ravn et al. (2007) introduce a market structure into the model which implies a strong decline in the mark up in the case of a government spending shock in order to generate a positive consumption effect. Monacelli et al. (2008) introduce a utility function which implies a stronger comovement between hours worked and consumption in order to generate the same effect. Gali et al. (2007) generate a positive effect on private consumption by introducing substantial capital market imperfections in the form of liquidity constrained households. Ratto et al. (2009a) estimate a first year multiplier for government consumption shocks of around 0.6 with an estimated share of liquidity constrained households of about 30% for the euro area, similar for government investment but lower for transfers. Private consumption by liquidity-constrained households rises in response to a government spending shock, but that of non-constrained households falls, and aggregate consumption declines. Coenen and Straub (2005) also find for a similar share of non-Ricardian households a short-lived rise in liquidity-constrained consumption, but falling below its steady state level after a few quarters, and a decline in aggregate consumption. It appears that one needs extreme shares of liquidity constrained households - i. e. households who don't have access to capital markets at all - in order to generate at least a non negative response of private consumption. This seems to be at odds with observed estimates of the share of liquidity constrained households. Credit constraints constitute an attractive alternative hypothesis. Given the uncertainty about income and wealth developments of borrowers, banks typically impose collateral constraints. This paper therefore explores the consequences for fiscal policy of this credit market friction.

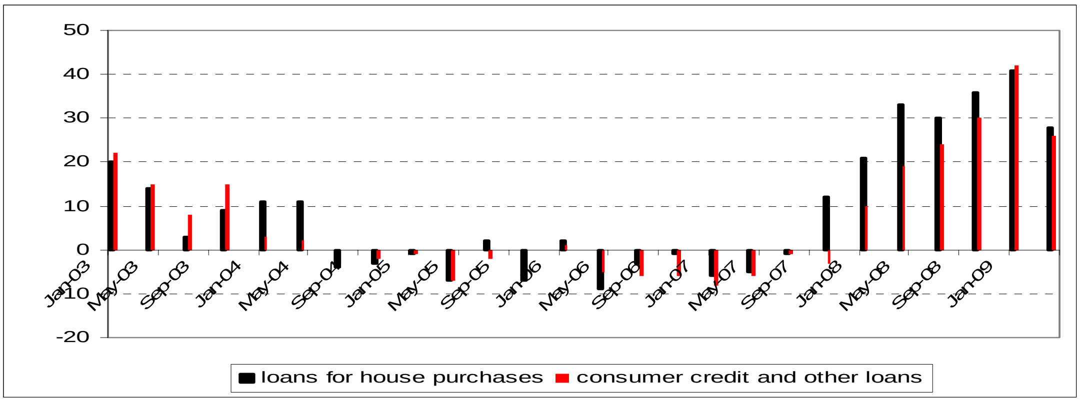
3. Tightening of Credit constraints

Since the onset of the financial crisis there has been a sharp increase in credit constraints. The collapse of house prices in the US as well as in many European countries led to a sharp increase in defaulting loans. Banks responded to these credit losses by restricting mortgage lending and reducing credit supply. As a result, the subprime mortgage market in the US virtually collapsed. The freezing up of the interbank market in 2008 aggravated the situation and credit supply tightened further.

This section reviews some evidence based on bank lending surveys in the euro area and the US that show how credit constraints have tightened for households, in particular for house purchases. The surveys are addressed to senior loan officers of a representative sample of banks and are conducted at regular intervals. Figure 1 illustrates how credit standards tightened in the euro area since the beginning of 2008. It shows the net percentage of banks reporting a tightening of credit standards for loans to households for house purchase as well as consumer credit and other loans[4]. Even tough this net percentage lessened somewhat in the first quarter of 2009, there was still a further overall tightening of credit standards from an already elevated level. The main factors contributing to the continued net tightening of credit were expectations regarding general economic activity and housing market prospects as well as cost of funds and balance sheet constraints for banks.

Figure 1: Euro area: Credit standards applied to the approval of loans to households

(net percentages of banks reporting tightening credit standards)



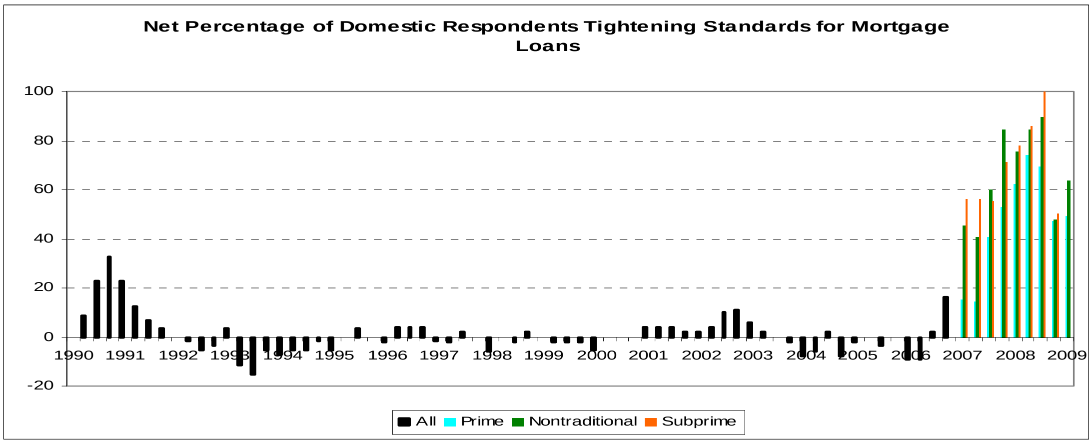
Source: ECB

For the US survey data from the Senior Loan Officer Opinion Survey goes back to the beginning of the 1990s and the evidence of tightening of credit constraints is even stronger (Figure 2). Since 2007 an increasing net percentages of domestic banks reported having tightened credit standards on residential mortgages. Even in the first quarter of 2009, a larger fraction of domestic respondents compared to the previous quarter reported having tightened their lending standards on prime and nontraditional residential mortgages[5]. As only two banks reported making any subprime mortgage loans that quarter, no response for the subprime category was reported in the survey. The evidence from these surveys suggest a considerable tightening of credit constraints for households since the beginning of the crisis.

[4] The net percentage is defined as the difference between the sum of the percentages of banks responding "tightened considerably" and "tightened somewhat", and the sum of the percentages of banks responding "eased somewhat" and "eased considerably".

[5] A similar tightening of lending standards was reported for revolving home equity lines of credit.

Figure 2: US: Credit standards applied to the approval of loans to households
(net percentages of banks reporting tightening credit standards)



Source: FRB, Senior Loan Officer Opinion Survey of Bank Lending Practices

4. The Model

We consider a two region world economy where we distinguish between the European Union and the rest of the world. There are three production sectors in each region, namely a sector producing tradables, non tradables and houses. We distinguish between Ricardian households which have full access to financial markets, credit constrained households facing a collateral constraint on their borrowing and liquidity constrained households which do not engage in financial markets. And there is a monetary and fiscal authority, both following rules based stabilisation policies. Behavioural and technological relationships can be subject to autocorrelated shocks denoted by U_t^k, where *k* stands for the type of shock. The logarithm of U_t^k[6] will generally be autocorrelated with autocorrelation coefficient ρ^k and innovation ε_t^k.

4.1 Firms:

There is a tradable and a non tradable sector, and there is a housing sector.

4.1.1 Producers of tradables and non tradables

Firms operating in the tradable and non tradable sector are indexed by *T* and *NT* respectively *j=(T,NT)*. Each firm produces a variety of the domestic good which is an imperfect substitute for varieties produced by other firms. Because of imperfect substitutability, firms are monopolistically competitive in the goods market and face a demand function for goods. Domestic firms in the tradable sector sell consumption goods and services to private domestic and foreign households and the domestic and foreign government and they sell investment and intermediate goods to other domestic and foreign firms. The non tradable sector sells consumption goods and services only to domestic households and the domestic government and they sell investment and intermediate goods only to domestic firms including the

[6] Lower cases denote logarithms, i.e. $z_t = log(Z_t)$. Lower cases are also used for ratios and rates. In particular we define $p_t^j = P_t^j / P_t^{GDP}$ as the relative price of good j w. r. t. the GDP deflator

residential construction sector. Preferences for varieties of tradables and non tradables can differ resulting in different mark ups for the tradable and non tradable sector.

Output is produced with a CES production function nesting a Cobb Douglas technology for value added using capital K_t^j and production workers $L_t^j - LO_t^j$, augmented with public capital K_t^G , and a CES function for domestically produced (*INTD)*, imported (*INTF)* and non-tradable intermediates *INTNT* .

(1) $$O_t^j = \left\{ (1-s_{\text{int}})^{\frac{1}{\sigma in}} . Y^{j\,(\frac{\sigma in-1}{\sigma in})} + s_{\text{int}}^{\frac{1}{\sigma in}} . INT^{j\,(\frac{\sigma in-1}{\sigma in})} \right\}^{\frac{\sigma in}{\sigma in-1}}$$

where

(2) $$Y_t^j = (ucap_t^j K_t^j)^{1-\alpha} (L_t^j - LO_t^j)^{\alpha} U_t^{Y\,\alpha} \left(K_t^G\right)^{\alpha_G}, \qquad \text{with } L_t^j = \left[\int_0^1 L_t^{i,j\,\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}.$$

and

(3)

$$INT_t^j = \left\{ s_T^{\;1/\sigma nt} \left[\left\{ sdom^{\frac{1}{\sigma}} INTD^{\left(\frac{\sigma-1}{\sigma}\right)} + (1-sdom)^{\frac{1}{\sigma}} INTF^{\left(\frac{\sigma-1}{\sigma}\right)} \right\}^{(\frac{\sigma}{\sigma-1})} \right]^{(\frac{\sigma nt-1}{\sigma nt})} + (1-s_T)^{1/\sigma nt} INTNT^{(\frac{\sigma nt-1}{\sigma nt})} \right\}^{(\frac{\sigma nt}{\sigma nt-1})}$$

The term LO_t^j represents overhead labour. Total employment of the firm L_t^j is itself a CES aggregate of labour supplied by individual households *i.* The parameter $\theta > 1$ determines the degree of substitutability among different types of labour. Firms also decide about the degree of capacity utilisation ($UCAP_t^j$). There is an economy wide technology shock U_t^Y. The objective of the firm is to maximise profits *Pr*

(4) $$\Pr_t^j = p_t^j Y_t^j - w_t L_t^j - i_t^K p_t^{K,j} K_t^j - (adj^P(P_t^j) + adj^L(L_t^j) + adj^{UCAP}(ucap_t^j)).$$

where i^K denotes the rental rate of capital. Firms also face technological and regulatory constraints which restrict their price setting, employment and capacity utilisation decisions. Price setting rigidities can be the result of the internal organisation of the firm or specific customer-firm relationships associated with certain market structures. Costs of adjusting labour have a strong job specific component (e.g. training costs) but higher employment adjustment costs may also arise in heavily regulated labour markets with search frictions. Costs associated with the utilisation of capital can result from higher maintenance costs associated with a more intensive use of a piece of capital equipment. The following convex functional forms are chosen

$$adj^L(L_t^j) = w_t(L_t^j u_t^L + \frac{\gamma_L}{2}\Delta L_t^{j\,2})$$

(5) $$adj^P(P_t^j) = \frac{\gamma_P}{2}\frac{(P_t^j - P_{t-1}^j)^2}{P_{t-1}^j}$$

$$adj^{UCAP}(ucap_t^j) = PI_t K_t(\gamma_{ucap,1}(ucap_t^j - 1) + \frac{\gamma_{ucap,2}}{2}(ucap_t^j - 1)^2)$$

The firm determines labour input, capital services and prices optimally in each period given the technological and administrative constraints as well as demand conditions. The first order conditions are given by:

(6a) $$\frac{\partial \Pr_t^j}{\partial L_t^j} \Rightarrow \left(\frac{\partial O_t^j}{\partial L_t^j}\eta_t^j - w_t u_t^L - w_t \gamma_L \Delta L_t^j + E_t(w_{t+1}\frac{\gamma_L}{(1+r_t)}\Delta L_{t+1}^j)\right) = w_t$$

(6b) $$\frac{\partial \Pr_t^j}{\partial K_t^j} \Rightarrow \left(\frac{\partial O_t^j}{\partial K_t^j}\eta_t^j\right) = i_t^K p_t^{K,j}$$

(6c) $$\frac{\partial \Pr_t^j}{\partial ucap_t^j} \Rightarrow \left(\frac{\partial O_t^j}{\partial ucap_t^j}\eta_t^j\right) = \frac{P_t^{K,j}}{P_t^j}K_t^j(\gamma_{ucap,1} + \gamma_{ucap,2}(ucap_t^j - 1))$$

(6d) $$\frac{\partial \Pr_t^j}{\partial O_t^j} \Rightarrow \eta_t^j = 1 - 1/\sigma^d - \gamma_P\left[\frac{1}{(1+r_t)}E_t\pi_{t+1}^j - \pi_t^j\right] \quad \text{with } \pi_t^j = P_t^j / P_{t-1}^j - 1 \; .$$

Where η_t is the Lagrange multiplier of the technological constraint and r_t is the real interest rate. Firms equate the marginal product of labour, net of marginal adjustment costs, to wage costs. As can be seen from the left hand side of equation (6a), the convex part of the adjustment cost function penalises in cost terms accelerations and decelerations of changes in employment. Equations (6b-c) jointly determine the optimal capital stock and capacity utilisation by equating the marginal value product of capital to the rental price and the marginal product of capital services to the marginal cost of increasing capacity. Equation (6d) defines the mark up factor as a function of the elasticity of substitution and changes in inflation. The average mark up is equal to the inverse of the price elasticity of demand. We follow the empirical literature and allow for additional backward looking elements by assuming that a fraction (*1-sfp*) of firms index price increases to inflation in t-1. Finally we also allow for a mark up shock. This leads to the following specification:

(6d') $$\eta_t^j = 1 - 1/\sigma^d - \gamma_P\left[\beta(sfpE_t\pi_{t+1}^j + (1-sfp)\pi_{t-1}^j) - \pi_t^j\right] - u_t^\eta \qquad 0 \le sfp \le 1$$

4.1.2 Residential construction

Firms *h* in the residential construction sector use new land (J_t^{Land}) sold by (Ricardian) households and non tradable goods ($J_t^{inp,H}$) to produce new houses using a CES technology

(7) $$J_t^H = \left(s_L^{\frac{1}{\sigma L}} J_t^{Land \frac{(\sigma L - 1)}{\sigma L}} + (1 - s_L)^{\frac{1}{\sigma L}} J_t^{inp,H \frac{(\sigma L - 1)}{\sigma L}} \right)$$

Firms in the residential construction sector are monopolistically competitive and face price adjustment costs, thus the mark up is given by

(10) $$\eta_t^H = 1 - 1/\sigma^H - \gamma_H \left[\beta (sfp E_t \pi_{t+1}^H + (1 - sfp)\pi_{t-1}^H) - \pi_t^H \right] - u_t^H \qquad 0 \le sfp \le 1$$

New and existing houses are perfect substitutes. Thus households can make capital gains or suffer capital losses depending on houseprice fluctuations

4.2 Households:

The household sector consists of a continuum of households $h \in [0,1]$. There are $s^l \le 1$ households which are liquidity constrained and indexed by *l*. These households do not trade on asset markets and consume their disposable income each period. A fraction s^r of all households are Ricardian and indexed by *r* and s^c households are credit constrained and indexed by *c*. The period utility function is identical for each household type and separable in consumption (C_t^h) , leisure ($1 - L_t^h$) and housing services (H_t^h). We also allow for habit persistence in consumption and leisure. Thus temporal utility for consumption is given by

(11) $$U(C_t^h, 1 - L_t^h, H_t^h) = \log\left(C_t^h - hC_{t-1}\right) + \vartheta\left(1 - L_t^h\right)^{1-\kappa} + \omega \log\left(H_t^h\right)$$

All three types of households supply differentiated labour services to unions which maximise a joint utility function for each type of labour *i.* It is assumed that types of labour are distributed equally over the three household types. Nominal rigidity in wage setting is introduced by assuming that the household faces adjustment costs for changing wages. These adjustment costs are borne by the household.

4.2.1 Ricardian households

Ricardian households have full access to financial markets. They hold domestic government bonds($B_t^{G^r}$) and bonds issued by other domestic and foreign households ($B_t^r, B_t^{F,r}$), real capitals (K_t^j) of the tradable and non tradable sector as well as the stock of land ($Land_t$) which is still available for building new houses and cash balances (M_t^r). The household receives income from labour, financial assets, rental income from lending capital to firms, selling land to the residential construction sector plus profit income from firms owned by the household (tradables, non tradables, residential construction). We assume that all domestic firms are owned by Ricardian households. Income from labour is taxed at rate t^W, rental income at rate t^k and investors can receive an investment subsidy (itc_t). In addition households pay lump-sum taxes T^{LS}. We assume that income from financial wealth is subject to different types of risk. Domestic bonds yield risk-free nominal return equal to i_t. Domestic and foreign bonds are subject to (stochastic) risk premia linked to net foreign indebtedness. Current spending is allocated to consumption (C_t^r), investment in equipment and structures

(I_t^j) as well as residential investment ($I_t^{H,r}, I_t^{HLC,r}$). An equity premium on real assets arises because of uncertainty about the future value of real assets. The Lagrangian of this maximisation problem is given by

(12)

$$
\begin{aligned}
Max \quad V_0^r &= \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{r\,t} U(C_t^r, 1-L_t^r, H_t^r) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{r\,t} \left(\begin{array}{l}
(1+t_t^c) p_t^C C_t^r + \sum_j p_t^{K,j}(1-itc_t) I_t^j + p_t^H (1+t_t^c) I_t^{H,r} + p_t^H (1+t_t^c) I_t^{HLC,r} + (B_t^{G,r} + B_t^r) \\
+ rer_t B_t^{F,r} - (1+r_{t-1})(B_{t-1}^{G,r} + B_{t-1}^r) - (1+r_{t-1}^F)(1-risk(.)) rer_t B_{t-1}^{F,r} \\
- \sum_j ((1-t_t^k) i_{t-1}^{K,j} + t_t \delta^{k,j}) p_{t-1}^{K,j} K_{t-1}^j - (1-t_t^W) w_t L_t^r + \frac{\gamma_W}{2} \frac{\Delta W_t}{W_{t-1}}^2 - \\
((1-t^k) i_{t-1}^H + \delta^H) p_t^H H_{t-1}^{LC,r} - p_t^L J_t^{Land} - \sum_{j=1} \Pr_t^j - \Pr_t^H + T_t^{LS,r}
\end{array} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{r\,t} \left(\sum_j \xi_t^j (K_t^j - J_t^j - (1-\delta^{K,j}) K_{t-1}^j) \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \zeta_t^r \beta^{r\,t} \left(H_t^r - J_t^{H,r} - (1-\delta^H) H_{t-1}^{H,r} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \vartheta_t^r \beta^{r\,t} \left(H_t^{LC,r} - J_t^{HLC,r} - (1-\delta^H) H_{t-1}^{LC,r} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \xi_t^r \beta^{r\,t} \left(Land_t + J_t^{Land} - (1+g_t^L) Land_{t-1} \right)
\end{aligned}
$$

The investment decisions w.r.t. physical capital and housing are subject to convex adjustment costs, therefore we make a distinction between real investment expenditure (I_t^j, I_t^H) and physical investment (J_t^j, J_t^H). Investment expenditure of households including adjustment costs is given by

$$(13a) \quad I_t^j = J_t^j \left(1 + \frac{(\gamma_K^j + u_t^j)}{2} \left(\frac{J_t^j}{K_t^j} \right) \right) + \frac{\gamma_I^j}{2} (\Delta J_t^j)^2$$

$$(13b) \quad I_t^{H,r} = J_t^{H,r} \left(1 + \frac{(\gamma_H + u_t^H)}{2} \left(\frac{J_t^{H,r}}{H_t^r} \right) \right) + \frac{\gamma_{IH}}{2} (\Delta J_t^{H,r})^2$$

The budget constraint is written in real terms with all prices expressed relative to the GDP deflator (*P*). Investment is a composite of domestic and foreign goods. From the first order conditions we can derive the following consumption rule, where the ratio of the marginal utility of consumption in period t and t+1 is equated to the real interest rate adjusted for the rate of time preference

$$(14) \qquad \frac{\mathrm{E}_t (C_{t+1}^r - hC_t)}{C_t^r - hC_{t-1}} = \beta^r (1+r_t)$$

From the arbitrage condition of investment we can derive an investment rule which links capital formation to the shadow price of capital.

$$(15)\qquad \left((\gamma_K^j + u_t^j)\left(\frac{J_t^{K,j}}{K_{t-1}^j}\right) + \gamma_I^j \Delta J_t^{K,j}\right) - E_t\left(\frac{1}{(1+r+\pi_{t+1}^{GDP} - \pi_{t+1}^{K,j})}\Delta J_{t+1}^{K,i}\right) = \frac{\xi_t^j}{p_t^K(1-itc_t)} - 1$$

Where the shadow price of capital is given as the present discounted value of the rental income from physical capital

$$(16)\qquad \frac{\xi_t^j}{p_t^{K,j}} = \mathrm{E}_t\left(\frac{1}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^{K,j})}\frac{\xi_{t+1}^j}{p_{t+1}^{K,j}}(1-\delta^K)\right) + ((1-t_t^K)i_t^K + t_t^K \delta^{K,j}) = 0$$

From the FOC for housing investment we can derive a housing investment rule, which links investment to the shadow price of housing capital

$$(17)\qquad \left((\gamma_H + u_t^H)\left(\frac{J_t^{H,r}}{H_{t-1}^r}\right) + \gamma_{IH} \Delta J_t^{H,r}\right) - E_t\left(\frac{1}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^{H} - \Delta t_{t+1}^c)}\Delta J_{t+1}^{H,r}\right) = \frac{\zeta_t^r}{p_t^H(1+t_t^c)} - 1 .$$

The shadow price of housing capital can be represented as the present discounted value of the ratio of the marginal utility of housing services and consumption

(18)

$$\frac{\zeta_t^r}{p_t^H(1+t_t^c)} = \omega^r \frac{(C_t^r - hC_{t-1})(1+t_t^c)p_t^C}{H_t^r(1+t_t^c)p_t^H} + \mathrm{E}_t\left(\frac{1}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^{H} - \Delta t_{t+1}^c)}\frac{\zeta_{t+1}^r}{p_{t+1}^h(1+t_{t+1}^c)}(1-\delta^H)\right)$$

For the price of land we one obtain a (quasi) Hotelling rule

$$p_t^{Land} = \mathrm{E}_t\left(\frac{1}{(1+r_t)} p_{t+1}^{Land}(1+g_L)\right)$$

The growth rate of the price of land must guarantee a rate of return which can be earned by other assets, i. e. the growth rate of land must be equal to $r_t - g_L$.

4.2.2 Credit constrained households

Credit constrained households differ from Ricardian households in two respects. First they have a higher rate of time preference ($\beta^c < \beta^r$) and they face a collateral constraint on their borrowing. They borrow B_t^c exclusively from domestic Ricardian households. Ricardian households have the possibility to refinance themselves via the international capital market. The Lagrangian of this maximisation problem is given by

(19)

$$Max \quad V_0^c = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{c\,t} U(C_t^c, 1-L_t^c, H_t^c)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{c\,t} \left((1+t_t^c) p_t^C C_t^c + p_t^H (1+t_t^H) I_t^{H,c} - B_t^c + (1+r_{t-1}) B_t^c - (1-t_t^W) w_t L_t^c + \frac{\gamma_W}{2} \frac{\Delta W_t^2}{W_{t-1}} + T_t^{LS,c} \right)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \zeta_t^c \beta^{c\,t} \left(H_t^c - J_t^{H,c} - (1-\delta^H) H_{t-1}^c \right)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t \beta^{c\,t} \left(B_t^c - (1-\chi) p_t^H H_t^c \right)$$

From the first order conditions we can derive the following decision rules for consumption

$$(20) \qquad \frac{\mathrm{E}_t (C_{t+1}^c - hC_t)}{C_t^c - hC_{t-1}} = \beta^c \frac{(1+r_t)}{(1-\psi_t)}$$

And housing investment

$$(21) \qquad \left((\gamma_H + u_t^H) \left(\frac{J_t^{H,c}}{H_{t-1}^c} \right) + \gamma_{IH} \Delta J_t^{H,c} \right) - E_t \left(\frac{(1-\psi_t)}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^H - \Delta t_{t+1}^c)} \Delta J_{t+1}^{H,c} \right) = \frac{\zeta_t^c}{p_t^H (1+t_t^c)} - 1$$

Where again the shadow price of housing capital is the present discounted value of the ratio of the marginal utility of housing services and consumption

(22)

$$\frac{\zeta_t^c}{p_t^H (1+t_t^c)} = \omega^c \frac{(C_t^c - hC_{t-1})(1+t_t^c) p_t^C}{H_t^c (1+t_t^c) p_t^H} + \psi_t (1-\chi) + \mathrm{E}_t \left(\frac{(1-\psi_t)}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^H - \Delta t_{t+1}^c)} \frac{\zeta_{t+1}^c}{p_{t+1}^H (1+t_{t+1}^c)} (1-\delta^H) \right)$$

The major difference between credit constrained and Ricardian households is the presence of the Lagrange multiplier of the collateral constraint in both the consumption and the investment rule of the former. The term ψ_t acts like premium on the interest rate which fluctuates positively with the tightness of the constraint.

4.2.3 Liquidity constrained households

Liquidity constrained households do not optimize but simply consume their entire labour income at each date. Real consumption of household *k* is thus determined by net wage income plus transfers minus a lump-sum tax

$$(23) \qquad (1+t_t^c) P_t^c C_t^l = (1-t_t^w) W_t L_{t\,t}^l + TR_t^l - T_t^{LS,l}$$

It is assumed that liquidity constrained households possess the same utility function as Ricardian households.

4.2.4 Wage setting

A trade union is maximising a joint utility function for each type of labour i where it is assumed that types of labour are distributed equally over constrained and unconstrained households with their respective population weights. The trade union sets wages by maximising a weighted average of the utility functions of these households. The wage rule is obtained by equating a weighted average of the marginal utility of leisure to a weighted average of the marginal utility of consumption times the real wage, adjusted for a wage mark up

$$\text{(24)} \qquad \frac{s^c U^c_{1-L,t} + s^r U^r_{1-L,t} + s^l U^l_{1-L,t}}{s^c U^c_{c,t} + s^r U^r_{c,t} + s^l U^l_{c,t}} = \frac{(1-t^W_t)}{(1+t^C_t)} \frac{W_t}{P^C_t} \eta^W_t$$

where η^W_t is the wage mark up factor, with wage mark ups fluctuating around $1/\theta$ which is the inverse of the elasticity of substitution between different varieties of labour services. The trade union sets the consumption wage as a mark up over the reservation wage. The reservation wage is the ratio of the marginal utility of leisure to the marginal utility of consumption. This is a natural measure of the reservation wage. If this ratio is equal to the consumption wage, the household is indifferent between supplying an additional unit of labour and spending the additional income on consumption and not increasing labour supply. Fluctuation in the wage mark up arises because of wage adjustment costs and the fact that a fraction (*1-sfw*) of workers is indexing the growth rate of wages π^W_t to inflation in the previous period.

(25)

$$\eta^W_t = 1 - 1/\theta - \gamma_W/\theta \left\lfloor \beta(\pi^W_{t+1} - (1-sfw)\pi_t) - (\pi^W_t - (1-sfw)\pi_{t-1}) \right\rfloor \qquad 0 \le sfw \le 1$$

Combining (17) and (18) one can show that the (semi) elasticity of wage inflation with respect to the employment rate is given by (κ/γ_W), i. e. it is positively related to the inverse of the labour supply elasticity and inversely related to wage adjustment costs.

4.2.5 Aggregation

The aggregate of any household specific variable X^h_t in per capita terms is given by $X_t = \int_0^1 X^h_t dh = s^r X^r_t + s^c X^c_t + s^l X^l_t$ since households within each group are identical. Hence aggregate consumption is given by

$$\text{(26a)} \qquad C_t = s^r C^r_t + s^c C^c_t + s^l C^l_t$$

and aggregate employment is given by

$$\text{(26b)} \qquad L_t = s^r L^r_t + s^c L^c_t + s^l L^l_t \quad \text{with } L^r_t = L^c_t = L^l_t .$$

Since liquidity constrained households do not own financial assets we have $B_t^l = B_t^{l^F} = K_t^l = 0$ .Credit constrained households only engage in debt contracts with Ricardian households, therefore we have

$$(27) \quad B_t^c = \frac{s^r}{s^c} B_t^r .$$

4.3 Trade and the current account

So far we have only determined aggregate consumption, investment and government purchases but not the allocation of expenditure over domestic and foreign goods. In order to facilitate aggregation we assume that households, the government and the corporate sector have identical preferences across goods used for private consumption, public expenditure and investment. Let $Z^i \in \{C^i, I^i, C^{G,i}, I^{G,i}\}$ be demand of an individual household, investor or the government, and then their preferences are given by the following utility function

$$(28a) \quad Z^i = \left[(1 - s^M - u_t^M)^{\frac{1}{\sigma^M}} Z^{d^i \frac{\sigma^M - 1}{\sigma^M}} + (s^M + u_t^M)^{\frac{1}{\sigma^M}} Z^{f^i \frac{\sigma^M - 1}{\sigma^M}} \right]^{\frac{\sigma^M}{(\sigma^M - 1)}}$$

where the share parameter s^M can be subject to random shocks and Z^{d^i} and Z^{f^i} are indexes of demand across the continuum of differentiated goods produced respectively in the domestic economy and abroad, given by.

$$(28b) \quad Z^{d^i} = \left[\sum_{h=1}^{n} \left(\frac{1}{n} \right)^{\frac{1}{\sigma^d}} Z_h^{d^i \frac{\sigma^d - 1}{\sigma^d}} \right]^{\frac{\sigma^d}{\sigma^d - 1}} \quad , \quad Z^{f^i} = \left[\sum_{h=1}^{m} \left(\frac{1}{m} \right)^{\frac{1}{\sigma^f}} Z_h^{f^i \frac{\sigma^f - 1}{\sigma^f}} \right]^{\frac{\sigma^f}{\sigma^f - 1}}$$

The elasticity of substitution between bundles of domestic and foreign goods Z^{d^i} and Z^{f^i} is σ^M . Thus aggregate imports are given by

$$(29) \quad M_t = (s^M + u_t^M) \left[\rho^{PCPM} \frac{P_{t-1}^C}{P_{t-1}^M} + (1 - \rho^{PCPM}) \frac{P_t^C}{P_t^M} \right]^{\sigma^M} (C_t + I_t^{inp} + C_t^G + I_t^G)$$

where P^C and P^M is the (utility based) consumer price deflator and the lag structure captures delivery lags.. We assume similar demand behaviour in the rest of the world, therefore exports can be treated symmetrically and are given by

$$(30) \quad X_t = (s^{M,W} + u_t^X) \left(\rho^{PWPX} \frac{P_{t-1}^{C,F} E_{t-1}}{P_{t-1}^X} + (1 - \rho^{PWPX}) \frac{P_t^{C,F} E_t}{P_t^X} \right)^{\sigma^X} Y_t^F$$

where P_t^X, $P_t^{C,F}$ and Y_t^F are the export deflator, an index of world consumer prices (in foreign currency) and world demand. Prices for exports and imports are set by domestic and foreign exporters respectively. The exporters in both regions buy goods from their respective domestic producers and sell them in foreign markets. They transform domestic goods into exportables using a linear technology. Exporters act as monopolistic competitors in export markets and charge a mark-up over domestic prices. Thus export prices are given by

(31) $$\eta_t^X P_t^X = P_t$$

and import prices are given by

(32) $$\eta_t^M P_t^M = E_t P_t^F$$

Mark-up fluctuations arise because of price adjustment costs. There is also some backward indexation of prices since a fraction of exporters (*1-sfpx*) and (*1-sfpm*) is indexing changes of prices to past inflation. The mark ups for import and export prices is also subject to random shocks

(34) $$\eta_t^k = 1 - 1/\sigma^k - \gamma_{Pk}\left[\beta(sfp^k \cdot_t \pi_{t+1}^k + (1-sfp^k)\pi_{t-1}^k) - \pi_t^k\right] + u_t^{P,k} \qquad k = \{X, M\}$$

Exports and imports together with interest receipts/payments determine the evolution of net foreign assets denominated in domestic currency.

(35) $$E_t B_t^F = (1 + i_t^F) E_t B_{t-1}^F + P_t^X X_t - P_t^M M_t$$

4.4 Policy

We assume that monetary policy is partly rules based and partly discretionary. Policy responds to an output gap indicator of the business cycle. The output gap is not calculated as the difference between actual and efficient output but we try to use a measure that closely approximates the standard practice of output gap calculation as used for fiscal surveillance and monetary policy (see Denis et al. (2006)). Often a production function framework is used where the output gap is defined as deviation of capital and labour utilisation from their long run trends. Therefore we define the output gap as

(36) $$YGAP_t = \left(\frac{ucap_t}{ucap_t^{ss}}\right)^{(1-\alpha)} \left(\frac{L_t}{L_t^{ss}}\right)^{\alpha}.$$

where L_t^{ss} and $ucap_t^{ss}$ are moving average steady state employment rate and capacity utilisation:

(37) $$ucap_t^{ss} = (1-\rho^{ucap}) ucap_{t-1}^{ss} + \rho^{ucap} ucap_t^j$$

(38) $$L_t^{ss} = (1-\rho^{Lss}) L_{t-1}^{ss} + \rho^{Lss} L_t$$

which we restrict to move slowly in response to actual values.

Monetary policy is modelled via the following Taylor rule, which allows for some smoothness of the interest rate response to the inflation and output gap

$$
\begin{aligned}
(39)\qquad i_t &= \tau_{lag}^{INOM} i_{t-1} + (1-\tau_{lag}^{INOM})[r^{EQ} + \pi^T + \tau_{\pi}^{INOM}(\pi_t^C - \pi^T) + \tau_{y,1}^{INOM}\, ygap_{t-1}] \\
&\quad + \tau_{y,2}^{INOM}({}_t ygap_{t+1} - ygap_t) + u_t^{INOM}
\end{aligned}
$$

The Central bank has a constant inflation target π^T and it adjusts interest rates whenever actual consumer price inflation deviates from the target. The central bank also responds to the output gap. There is also some inertia in nominal interest rate setting. There is no active fiscal policy.

On fiscal policy, we distinguish on the expenditure side government consumption, government investment and transfer payments to households. Revenue consists of taxes on consumption as well as capital and labour income, and lump-sum taxes. Government debt (B_t) evolves according to

$$
(40)\qquad B_t = (1+i_t)B_{t-1} + P_t^C C_t^G + P_t^C I_t^G + TR_t - t_t^w W_t\, L_t - t_t^c P_t^c C_t - t_t^K i_t^K P_t^I K_{t-1} - T_t^{LS}\ .
$$

The labour income tax rate is used for controlling the debt to GDP ratio according to the following rule

$$
(41)\qquad \Delta t_t^w = \tau^B\left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right) + \tau^{DEF}\Delta\left(\frac{B_t}{Y_t P_t}\right)
$$

where b^T is the government debt target.

4.5 Sensitivity of credit constrained consumption to changes in income and interest rates

Both temporary and permanent fiscal expansions have only a negligible effect on Ricardian consumers since these respond to permanent income, which is hardly affected by temporary fiscal measures (and likely to be zero or even negative in the case of permanent fiscal actions). The question arises, how do credit constrained households respond to fiscal policy? Since they optimise an intertemporal utility function, their consumption decisions will also be based on a concept of permanent income. But how does the fact that they have a higher rate of time preference and the fact that current changes in financial wealth are constrained by the value of the housing stock affect their consumption response to changes in current income and the real interest rate ? In this section we compare the response of consumption for credit constrained and Ricardian households by focussing on the maximisation problem of credit constrained households (eq. 19 to 22) under the assumption of exogenous disposable income and real interest rates and contrast this to that of Ricardian households.

Figure 3 shows the strong co-movement between income and consumption for temporary income shocks. Credit-constrained households respond to the increase in current income by raising their consumption almost proportionately (their marginal propensity to consume is close to 0.9). Ricardian households, in contrast, do not raise their consumption by much as permanent income is not affected. As shown in Figure 4, the response of consumption to interest rates is very strong and exceeds the response of Ricardian consumers to temporary changes in real interest rates. This is explained by a strong increase of the Lagrange multiplier associated with the credit constraint. In the case of an interest rate increase, interest payments of (heavily indebted) households increase strongly which tightens the collateral constraint. For credit constrained households changes in the real interest rate exert an income effect on consumption. Given the timing convention in our model changes in current interest rates will lead to changes in interest payments in the following period. The analysis in this section shows that concerning changes in current income, credit constrained households behave similar to liquidity constrained households, while concerning changes in real interest rates they react even stronger than Ricardian households.

Figure 3: Response of consumption to changes in current income (absolute deviations)

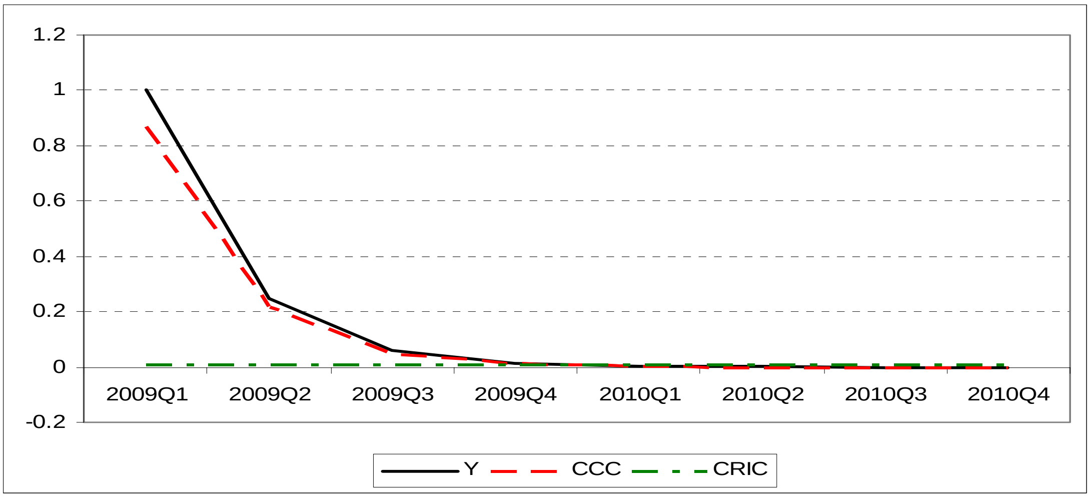
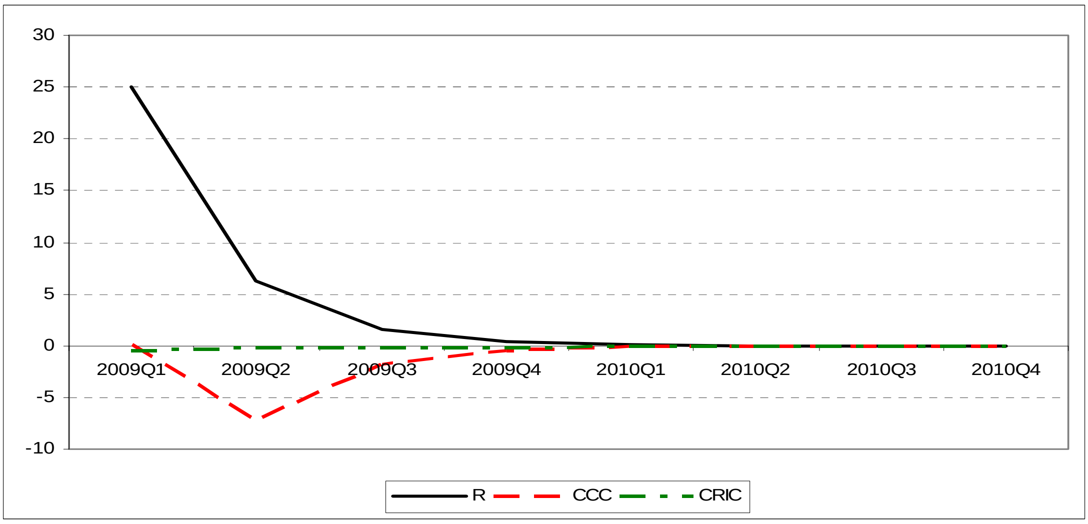


Figure 4: Response of consumption to changes in interest rates (% deviations)



5. Model calibration

The model used in this exercise consists of two regions: the European Union and the rest of the world. The regions are differentiated from one another by their economic size and the model is calibrated on bilateral trade flows. It incorporates some of the main stylised differences between the EU and the rest of world, where we base our calibration on estimates of the model on euro area and US data (see Ratto *et al*., 2009). Table 1 summarises the main differences between the two blocks. These are, for the EU, higher transfers and unemployment benefits, higher wage taxes, higher price rigidities and labour adjustment costs, and a lower elasticity of labour supply.

In terms of nominal and real rigidities, our estimates reveal clear differences which are largely consistent with prior expectations and other empirical evidence. This is most clear when it comes to price adjustment rigidities. European firms keep prices fixed for more quarters than US firms. Our estimates suggest that the duration of wage spells in the US is similar to those in the EA. There are however significant differences in the labour supply elasticity. A significantly higher elasticity in the US translates into a smaller response in US wages to changes in employment[7]. Another estimation result that coincides well with a priori beliefs on employment protection are higher labour adjustment costs in the EU. According to these estimates, administrative costs of increasing employment amount to about 13% of total additional wage costs in the EA and only 10% in the US. There is less evidence on differences in capital adjustment costs. Concerning financial market frictions, we assume 40 percent of households to be liquidity-constrained, which corresponds closely to our estimates. We have little knowledge on the share of credit-constrained households and we assume in our benchmark model (CC) half of the non-liquidity constrained households to be credit-constrained. We compare this to an alternative model *RIC* where the credit-constrained group is shifted to the non-constrained Ricardian group and the ratios liquidity constrained–credit constrained–non constrained are 40-0-60. This allows us to focus on the impact the introduction of credit-constrained households makes in the response of the private sector to the fiscal expansions. The loan-to-value ratio ($1-\chi$) is set at 0.75 for both regions, calibrated to fit a mortgage debt ratio as share of GDP on the baseline of around 50 percent. The estimated Taylor rules do not point to sizeable differences in monetary policy behaviour and we set these parameters identical.

Another important stylised fact is the difference between the EU and the US in the generosity of the transfer system. The share of government transfers to households is higher in the Euro area than in the US. The main difference are a more generous unemployment benefit system and a higher emphasis on PAYG pension schemes in the EU. Apart from the generosity difference there is also a difference in benefit-and pension entitlements because of a higher unemployment rate and a higher old age dependency ratio in the EU compared to the US.

[7] This is consistent with our Phillips curve estimates which also show a stronger response of wage inflation to unemployment in the Euro area compared to the US.

Table 1: Model calibration

	EU	*US*
Nom. Rigidities:		
Avg. duration between price adjustments (Quarters)	5.5	5
Avg. wage contract length (Quarters)	4.5	4.5
Real Rigidities:		
Labour adjustment cost (% of total add. wage costs) (γ_L)	13	10
Labour supply elasticity ($1/\kappa$)	1/5	1/3
Semi-wage elasticity w.r.t. employment rate (κ/γ_w)	0.33	0.20
Capital adjustment cost (γ_K)	20	20
Investment adjustment cost (γ_I)	75	75
Consumption:		
Share of liquidity-constrained consumers s^l	0.4	0.4
Share of credit-constrained consumers s^c	0.3 (CC)	0.3 (CC)
	0 (RIC)	0 (RIC)
Share of non-constrained consumers s^r	0.3 (CC)	0.3 (CC)
	0.6 (RIC)	0.6 (RIC)
Downpayment rate χ	0.25	0.25
Habit persistence h	0.7	0.7
Monetary policy:		
Lagged interest rate τ_{lag}^{INOM}	0.85	0.85
Consumer price inflation τ_{π}^{INOM}	1.5	1.5
Output gap τ_{Y}^{INOM}	0.05	0.05
National accounts decomposition:		
Consumption	0.59	0.64
Investment tradedables	0.06	0.05
Investment non-tradables	0.07	0.06
Investment residential	0.06	0.06
Government consumption	0.18	0.15
Government investment	0.04	0.04
Exports	0.18	0.15
Imports	0.18	0.15
Transfers to households	0.16	0.13

6. Fiscal shocks

6.1 Government consumption shock

To show the difference the introduction of credit constraints has made in the model we compare the model with credit constraints (CC) with the model that excludes this group (RIC). In this section we show temporary (one year) global fiscal shocks (government consumption (unproductive) and labour taxes) applied to both regions at the same time and standardised to 1 per cent of (baseline) GDP[8]. The fiscal rule that returns the debt to GDP ratio to baseline levels is turned off for the first year to see the impact of the shock on budget balances, but from the second year onwards labour taxes are raised to return the debt to GDP ratio to baseline. Hence, these scenarios are budgetary neutral in the medium run.

The first scenario shown in Figure 5 is a temporary increase in *government consumption* and the results shown are for the EU. This temporary impulse raises GDP by 1 per cent in the model with credit constraints *CC* model and 0.95 per cent in the model without (*RIC)*. The main difference between the two model variants is the response of private consumption. Under the standard monetary policy assumption, in the *RIC* model, private consumption falls in response to the increase in public consumption, a well documented feature of many DSGE models[9]. This seems at first sight in conflict with the findings of Gali *et al.* (2007), who show that allowing for a fraction of liquidity constrained consumers exceeding 25 per cent, a model with sticky prices can account for a positive consumption response to a government spending shock. But their result depends crucially on the assumed labour adjustment cost parameter γ_L. Gali *et al.* assume no nominal wage rigidities and no labour adjustment costs. However, empirical estimates show these parameters to be significantly different from zero. A sensitivity analysis in Ratto *et al.* (2009) shows that when these parameters tend to zero (as assumed in Gali *et al* (2007)), the consumption response to a government spending shocks tends to become positive in our model too[10]. Interestingly, in the model with credit-constrained households, there is a positive co-movement between public and private consumption even with non-zero labour adjustment costs. This is completely driven by the response of consumption by credit constrained households, who act more like liquidity-constrained households in response to temporary government consumption shocks and raise their consumption. Residential investment falls due to the increase in real interest rates.

The effects of fiscal policy shocks depend crucially on the monetary policy assumptions. Empirical studies that hold interest rates constant show larger multipliers than studies that allow for interest rate responses by central banks. In order to show the sensitivity of the results to the monetary policy assumption, we compare the results to an alternative assumption of a fully accommodative monetary policy, in which interest rates are kept unchanged in the first year when the stimulus occurs, and resume to the normal response in the years thereafter. The effects are significantly stronger under this more accommodative monetary policy (Figure 6). As in this case monetary policy does not react to the increase in

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[8] A wider range of fiscal shocks is described in Roeger and in 't Veld (2009). There we also discuss *permanent* shocks, which have much smaller multipliers which, when financed by increases in labour taxes, generally become negative in the long run. In those cases households anticipate future increases in taxes and reduce their consumption and save more.

[9] See e.g. Coenen and Straub (2007).

[10] The economic interpretation of this result is simple. Negligible wage and labour adjustment costs imply a stronger positive short run impact of an increase in government consumption on labour income and therefore a stronger response of private consumption.

inflation in the year the fiscal stimulus occurs, there is a sharp fall in the real interest rate and this increases aggregate demand. The model with credit constraints displays an even stronger increase in aggregate consumption. Credit constrained consumers react strongly with a large increase in consumption, larger than liquidity constrained consumers, as there is a small loosening of the collateral constraint due to a simultaneous increase in the housing stock, and because there is an additional effect from lower real interest rates (see section 3.5) . Notice though that even in the *RIC* model without credit-constraints there is an increase in aggregate consumption with even a small increase in consumption by Ricardian non-constrained households. Another difference with Figure 5 is that now there is an increase in corporate and residential investment due to the fall in real interest rates. This effect is stronger in the model with credit constraints.

6.2 Labour tax reduction

The GDP effect of a temporary reduction in *labour taxes* is roughly half that of an increase in spending, with a higher increase in savings (see Figure 7). There is however a significant difference between the two alternative models. In the model without credit constrained households (*RIC*), GDP rises by only 0.3 per cent, while the increase is twice as large in the model with credit constraints (*CC*). Ricardian, non-constrained households hardly respond to the temporary reduction in taxes as permanent income is not much affected. In contrast, credit constraint households have a higher marginal propensity to consume out of transitory tax reductions and respond in a similar way as liquidity constrained households by increasing their consumption. As a result, the increase in aggregate consumption is twice as large in the model with credit constraints. Corporate investment is down by more in the model with credit constraints as real interest rates rise by more. Housing investment by Ricardian nonconstrained households does not change much, but credit constrained households can raise their housing investment after the tax reduction. The fall in real wages is smaller in the model with credit constraints due to higher consumption (wealth effect).

When the tax reduction is accompanied by a fall in real interest rates (monetary accommodation - Figure 8) the effects are significantly larger. The response of liquidity constrained consumers is identical but credit constrained consumers raise their consumption now by more, as the additional effect from lower real interest rates boosts their disposable income. Corporate and residential investment are higher due to the fall in real interest rates, and this effect is stronger in the model with credit constraints. There is also now an increase in real wages in the model with credit constraints due to higher consumption.

6.3 Spillover effects of temporary fiscal shocks

The fiscal shocks discussed in the previous section were global expansions in both regions. To illustrate the importance of the spillover effects, Table 2 below shows the difference between global expansions in both regions and fiscal expansions in one region alone, in the model that includes credit constrained households (*CC*). The table shows the first year GDP effects for the same standardised temporary (one year) fiscal shocks, in the first column for a shock in the EU, in the second column in rest of the world, and in the third column for a global shock in both regions together (as discussed above). Government spending shocks have higher fiscal multipliers than revenue shocks. Spillovers of a fiscal expansion in the EU to the rest of the world are around 10 percent, while the reversed spillovers of a shock in the other region to the EU are somewhat larger, reflecting the difference in size and trade openness. Multipliers are generally smaller in the EU due to higher nominal and real rigidities and benefit and transfer generosity.

In case of a monetary accommodation the effects are larger as the sharp fall in the real interest rate increases aggregate demand. The fiscal stimulus in one single region is also accompanied by a depreciation of the exchange rate which boosts trade in the country concerned, but reduces the spillover effects to the other region. Under an accommodative monetary stance, a coordinated global fiscal expansion has also larger effects, with the multipliers ranging from 0.7 for tax reductions to 1.5 for spending increases.

Table 2 First year GDP effects of temporary fiscal shocks of 1% of GDP

	EU	RoW	Global
Government consumption			
EU GDP	0.74	0.26	0.99
RoW GDP	0.09	0.96	1.04
Government consumption with monetary accommodation			
EU GDP	1.23	0.08	1.40
RoW GDP	0.04	1.48	1.52
Labour tax			
EU GDP	0.41	0.12	0.53
RoW GDP	0.04	0.52	0.56
Labour tax with monetary accommodation			
EU GDP	0.60	0.05	0.68
RoW GDP	0.02	0.74	0.76

Note: GDP difference from baseline in first year of simulation, for resp. EU acting alone, RoW acting alone and global coordinated expansions. All shocks are credibly temporary for one year and of equal size, 1% of baseline GDP.

7. Conclusions

The current financial crisis has renewed interest in discretionary fiscal policy. Using a DSGE model with housing investment and credit constrained households this paper has shown that fiscal policy can be more effective at the current juncture with tigther credit constraints and deflationary shocks that make a more accommodative monetary policy reaction to a fiscal stimulus more likely. We find that temporary fiscal policy shocks can have sizeable effects larger for spending shocks than for tax reductions. Second, the introduction of credit-constrained households raises the multiplier for tax shocks, almost doubling the impact when half the Ricardian households are assumed to be in fact credit-constrained. This suggests that at the present juncture, with a tightening of credit constraints as a result of the financial crisis, fiscal policy might be more effective than in the past. Third, the response of monetary policy to a fiscal stimulus matters greatly. If nominal interest rates are kept unchanged, and real interest rates fall, the demand stimulus is much larger. Consumption of credit constrained households then increases by even more and the model generates a positive comovement between government spending and consumption. Fourth, spillover effects of fiscal shocks are positive, and effects of a joint fiscal stimulus are larger than when acting alone.

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Figure 5 Temporary increase government consumption

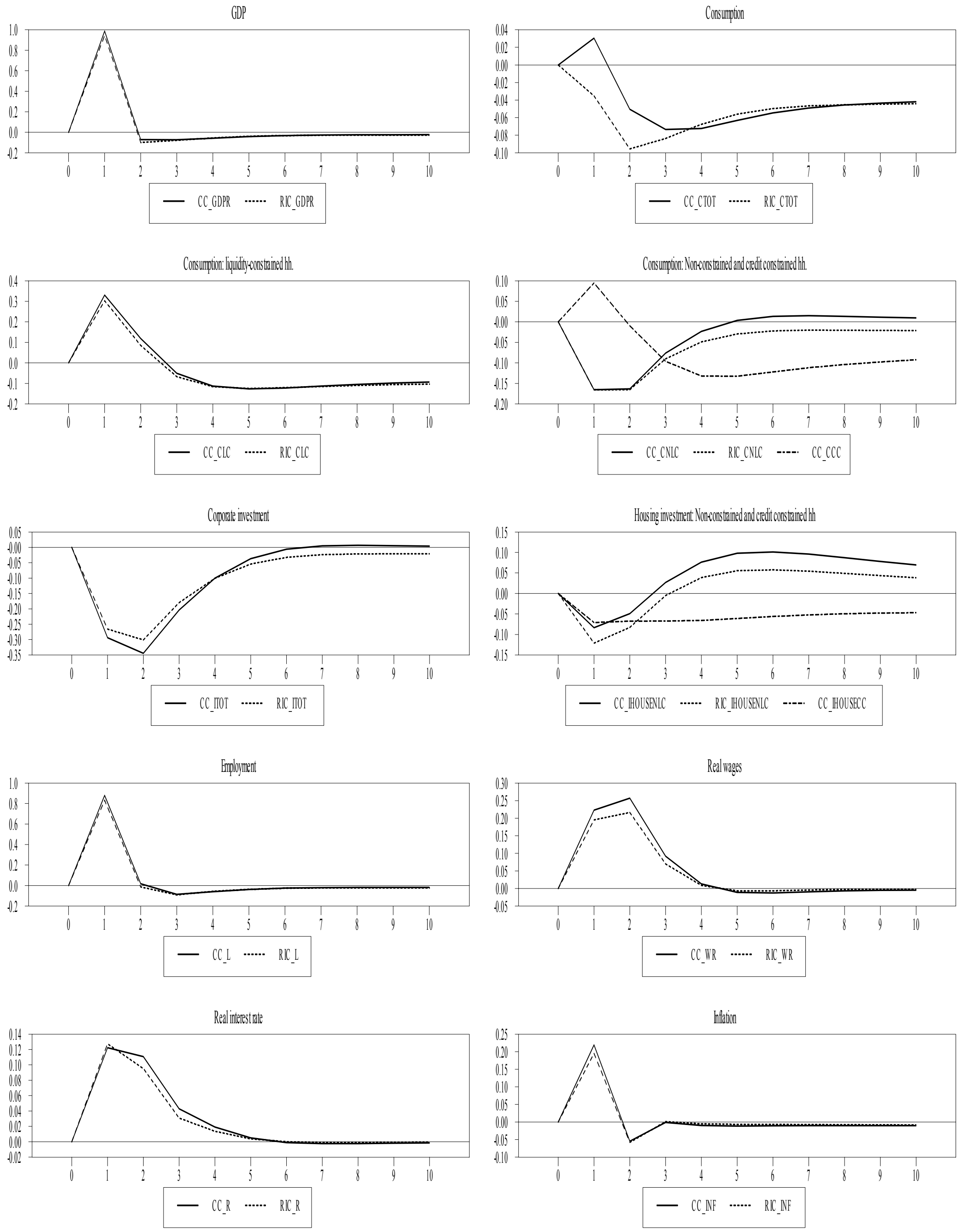

Figure 6 Temporary increase government consumption with monetary accommodation

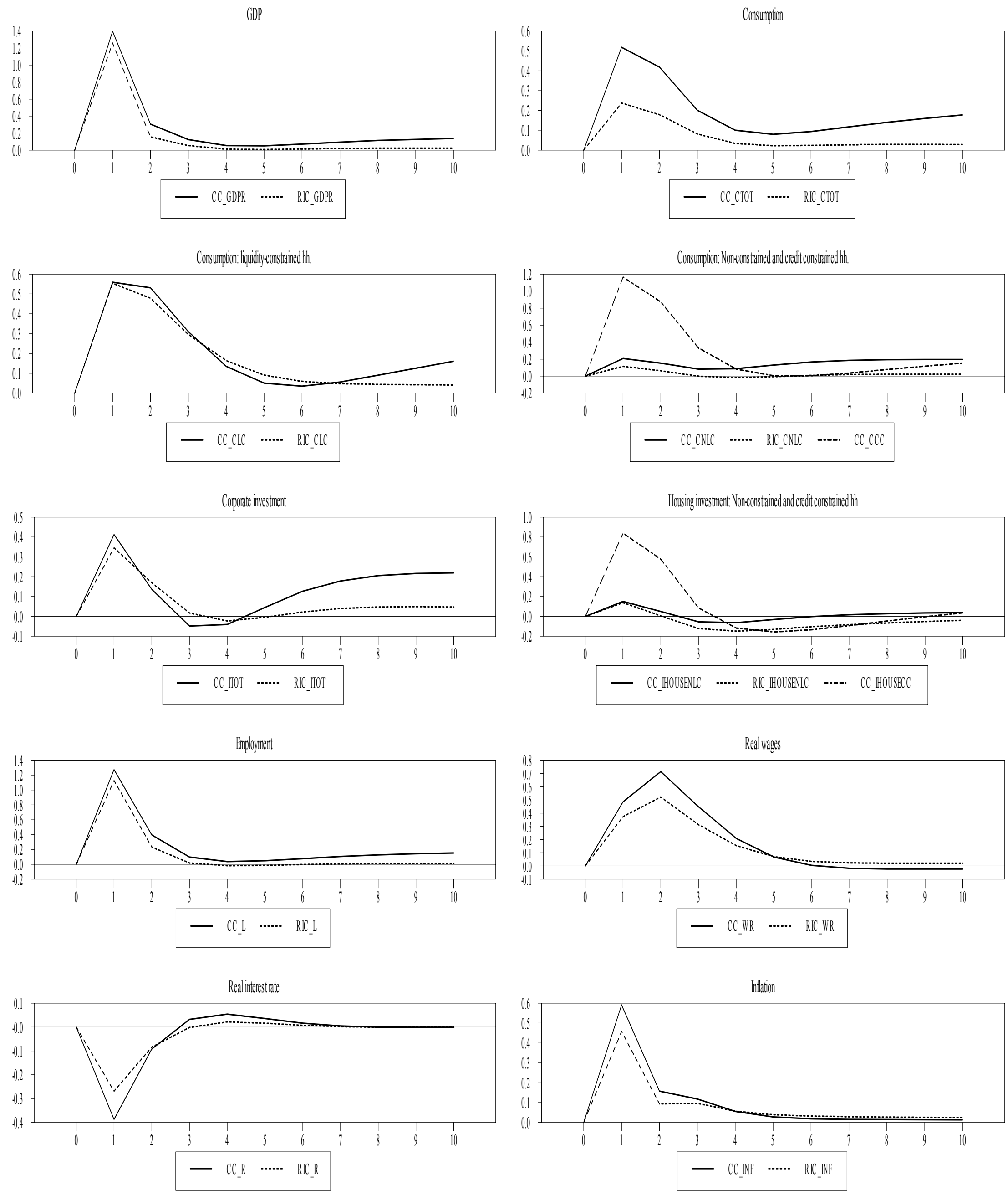

Figure 7 Temporary reduction labour taxes

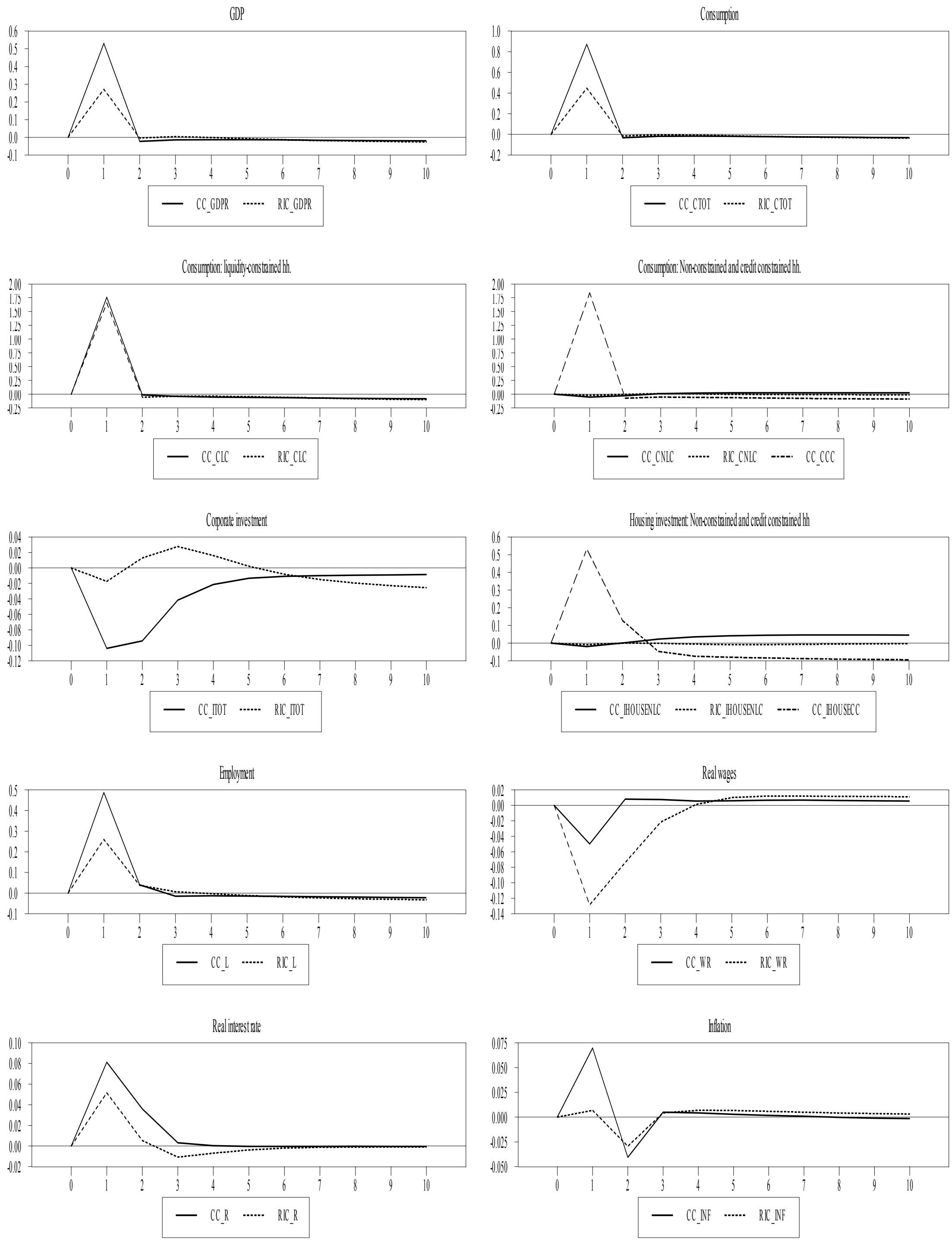

Figure 8 Temporary reduction labour taxes with monetary accommodation