FISCAL POLICY MULTIPLIERS IN THE EU DURING THE CREDIT CRISIS: A DSGE ANALYSIS

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This paper uses a multi region DSGE model with collateral constrained households and residential investment to examine the effectiveness of fiscal policy stimulus measures in a credit crisis. The paper explores alternative scenarios which differ by the type of budgetary measure, its length, the degree of monetary accommodation and the level of international coordination. It is found that an increase in households facing credit constraints and the fact that the zero lower bound on nominal interest rates has become binding both increase the effectiveness of temporary fiscal stimulus measures.

1 Introduction

The depth of the global recession has led to a revival of interest in discretionary fiscal policy. The current recession has proved to be the deepest and longest since the 1930s and recovery remains uncertain and fragile. But the general policy response to the downturn has been swift and decisive. Aside from government interventions dealing with the liquidity and solvency problems of the financial sector, including unconventional measures in the form of quantitative easing, the European Economic Recovery Plan (EERP) was launched back in December 2008. The objective of the EERP was to restore confidence and bolster demand through a coordinated injection of purchasing power into the economy complemented by strategic investments and measures to shore up business and labour markets. Governments across the world have implemented large fiscal stimulus packages. In the European Union, the overall discretionary fiscal stimulus over 2009 and 2010 amounts to more than 2 per cent of GDP, and this is further enhanced by the workings of automatic stabilisers.

There exists widespread scepticism on the effectiveness of fiscal policy as a general instrument for stabilisation purposes, and it is frequently argued that it is best to let fiscal policy have its main countercyclical impact through the operation of automatic stabilisers. But with limited room for a stronger monetary policy response, the effectiveness of temporary fiscal measures in stabilising the economy needed reexamination. There are several reasons why a temporary fiscal stimulus can be more powerful in the current financial crisis. First, to the extent that this recession is purely demand driven, fiscal policy can be more effective than in previous recessions that were to a large extent caused by supply side factors (e.g., oil price shocks). When the economy is hit by supply shocks there is little active discretionary fiscal policy can do. A second factor that justified earlier scepticism on fiscal policy was the rapid financial liberalisation. When more and more households acquired access to financial markets and were able to smooth their consumption, fiscal policy became less powerful. The financial crisis has had a profound effect on credit conditions and led to a sharp tightening in lending practices. With the sharp increase in the share of credit constrained households, fiscal policy has become more effective. Third, for those economies where interest rates are near their zero lower bound, monetary policy can be accommodative to the fiscal expansion and the resulting increase in inflation and decrease in real interest rates form an additional indirect channel through which growth can be supported. Fourth, as the financial crisis has long-lasting consequences and the recovery is expected to be

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fragile and feeble, the often argued disadvantage of fiscal policy that it is not timely due to long implementation lags, seems less relevant at the current juncture.

This paper examines the effectiveness of fiscal policy measures. In many of the euro area countries, fiscal multipliers are larger than under "normal" circumstances due to the presence of credit constrained households and nominal interest rates at the zero lower bound. This not necessarily holds in the Member States in Central and Eastern Europe. One particular aspect in which these economies differ from the old member states is that a larger share of household debt is denominated in foreign currencies (like, e.g., in Latvia and Hungary). This can have a profound effect on household spending when the domestic currency depreciates *vis-à-vis* the currency in which debt is denominated. A second aspect in which many of these countries differ from the old EU15 is that monetary policy had less space to be accommodative.

We use a modern dynamic stochastic general equilibrium (DGSE) model in which collateral 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 collateral constraints,[1] 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 second reason why fiscal policy can be more powerful with deflationary shocks like the current financial crisis is that credit constrained consumers react even more strongly to a fall in real interest rates, which as argued above can occur when monetary policy can be accommodative towards the fiscal stimulus, and allow real interest rates to fall.

The rest of the paper is structured as follows. The next section starts with a brief overview of the fiscal measures that have been undertaken by the governments in the European Union. This is followed by a brief description of the QUEST III model, with particular emphasis on the household sector and collateral constrained households. The next section gives a review of the size of fiscal multipliers in this model for a range of fiscal instruments and under alternative assumptions. The following section then presents simulation results of a credit crisis and shows how a temporary fiscal stimulus can mitigate the output losses associated with the crisis.

2 Fiscal stimulus packages in the New Member States of the EU

The EU has combined structural reforms with active fiscal stimulus to address the economic downturn. Large fiscal stimulus packages have been implemented across the EU in 2009 and 2010.[2] The packages have broadly followed desirable general principles, *i.e.*, they were differentiated according to the available fiscal room for manoeuvre and relied on measures that were targeted, timely and temporary. Tables 1 and 2 give an overview of the fiscal stimulus measures implemented in the EU Member States, using a classification of measures in four broad categories: measures aimed at supporting household purchasing power, labour market measures, measures aimed at companies, and measures aimed at increasing/bringing forward investment. The dispersion of package sizes is considerable. On average in the EU, the fiscal stimulus in 2009 amounted to more than 1 percent of GDP and slightly less than that in 2010, with generally a strong emphasis on measures supporting household income. Many of the countries most affected by the

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

[2] The European Economic Recovery Programme (EERP) is estimated to total around 2 per cent of GDP over 2009-10, including EUR 20 billion (0.3 per cent of EU GDP) through loans funded by the European Investment Bank.

Table 1

Fiscal Stimulus Measures in EU Member States: 2009 and 2010
2009

Country	Total Stimulus Measures *(percent of GDP)*	A Supporting Household Purchasing Power *(percent of GDP)*	B Labour Market Measures *(percent of GDP)*	C Measures Aimed at Companies *(percent of GDP)*	D Increasing/ Bringing Forward Investment *(percent of GDP)*
BE	0.94	0.38	0.03	0.20	0.00
BG	0.00	0.00	0.00	0.00	0.00
CZ	1.99	0.65	0.56	0.68	0.10
DK	–0.08	0.00	0.00	–0.08	0.00
DE	1.71	0.62	0.22	0.46	0.41
EE	0.00	0.00	0.00	0.00	0.00
IE	0.54	0.40	0.00	0.14	0.00
EL	0.19	0.12	0.05	0.01	0.00
ES	0.79	0.33	0.11	0.35	0.00
FR	0.65	0.14	0.11	0.27	0.14
IT	0.57	0.20	0.16	0.21	–0.01
CY	1.22	0.89	0.04	0.29	0.01
LV	1.76	1.73	0.00	0.04	0.00
LT	0.05	0.00	0.05	0.00	0.00
LU	1.90	1.50	0.34	0.06	0.00
HU	0.01	0.00	0.01	0.00	0.00
MT	0.56	0.00	0.00	0.48	0.09
NL	0.88	0.00	0.11	0.27	0.16
AT	1.39	1.09	0.23	0.02	0.04
PL	0.92	0.01	0.75	0.16	0.00
PT	0.29	0.00	0.16	0.09	0.03
RO	1.81	0.16	0.02	1.63	0.00
SI	0.86	0.04	0.18	0.30	0.34
SK	0.34	0.23	0.05	0.05	0.02
FI	1.29	1.04	0.02	0.23	0.00
SE	0.73	0.17	0.56	0.00	0.00
UK	1.72	1.35	0.07	0.28	0.02
EU27	1.06	0.46	0.16	0.29	0.12
EUR16	0.98	0.36	0.14	0.29	0.15

Table 1 (continued)

Fiscal Stimulus Measures in EU Member States: 2009 and 2010
2010

Country	Total Stimulus Measures (percent of GDP)	A Supporting Household Purchasing Power (percent of GDP)	B Labour Market Measures (percent of GDP)	C Measures Aimed at Companies (percent of GDP)	D Increasing/ Bringing Forward Investment (percent of GDP)
BE	0.75	0.42	0.03	0.00	0.00
BG	0.00	0.00	0.00	0.00	0.00
CZ	1.37	0.74	0.00	0.57	0.00
DK	0.11	0.00	0.00	0.11	0.00
DE	2.42	1.30	0.23	0.35	0.54
EE	0.00	0.00	0.00	0.00	0.00
IE	0.68	0.45	0.00	0.24	0.00
EL	0.00	0.00	0.00	0.00	0.00
ES	0.59	0.00	0.03	0.08	0.48
FR	0.25	0.01	0.00	0.17	0.07
IT	0.49	0.00	0.22	0.15	0.12
CY	0.98	0.67	0.01	0.29	0.02
LV	0.30	0.26	0.00	0.05	0.00
LT	0.01	0.00	0.01	0.00	0.00
LU	1.65	1.44	0.00	0.22	0.00
HU	0.02	0.00	0.02	0.00	0.00
MT	1.23	0.00	0.14	0.84	0.26
NL	0.83	0.00	0.10	0.20	0.17
AT	1.61	1.33	0.23	0.04	0.00
PL	0.81	0.02	0.70	0.09	0.00
PT	0.12	0.00	0.00	0.12	0.00
RO	0.00	0.00	0.00	0.00	0.00
SI	0.47	0.00	0.37	0.10	0.00
SK	0.45	0.32	0.06	0.06	0.00
FI	2.06	1.51	0.02	0.52	0.00
SE	1.32	0.73	0.59	0.00	0.00
UK	0.61	0.39	0.16	0.04	0.01
EU27	0.95	0.42	0.15	0.17	0.19
EUR16	1.05	0.45	0.12	0.20	0.25

crisis, particularly among the new Member States, have had very limited room to implement stimulus measures (and have often predominantly adopted consolidation measures with a view to avoiding a further fall-out from the crisis).

3 The model

The model used in this exercise is an extended version of the QUEST III model (Ratto *et al.*, 2009) with collateral constrained households and residential investment (see Röger and in 't Veld, 2009).[3] We use a 6 region version of this model, calibrated for the euro area, the New Member States not part of the euro area, the old member states outside the euro area, the US, emerging Asia, 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 [4] will generally be autocorrelated with autocorrelation coefficient ρ^k and innovation ε_t^k.

3.1 Firms

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

3.1.1 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 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

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[3] See Röger, W. and J. in 't Veld (2009), "Fiscal Policy with Credit Constrained Households", *European Economy*, Economic Paper, No. 357, January, available at: http://ec.europa.eu/economy_finance/publications/publication13839_en.pdf

[4] 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

K_t^G, and a CES function for domestically produced (*INTD)*, imported (*INTF)* and non-tradable intermediates *INTNT* .

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

where:

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

and:

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

$$\left. + (1-s_T)^{1/\sigma tnt} INTNT^{(\frac{\sigma tnt-1}{\sigma tnt})} \right\}^{(\frac{\sigma tnt}{\sigma tnt-1})} \tag{3}$$

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*:

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

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:

$$adj^{L}(L_t^j) = w_t(L_t^j u_t^L + \frac{\gamma_L}{2}\Delta L_t^{j\,2})$$
$$adj^{P}(P_t^j) = \frac{\gamma_P}{2}\frac{(P_t^j - P_{t-1}^j)^2}{P_{t-1}^j} \tag{5}$$
$$adj^{UCAP}(ucap_t^j) = PI_t K_t(\gamma_{ucap,1}(ucap_t^j - 1) + \frac{\gamma_{ucap,2}}{2}(ucap_t^j - 1)^2)$$

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:

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

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

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

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

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:

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

3.1.2 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:

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

Firms in the residential construction sector are monopolistically competitive and face price adjustment costs. Thus the mark up is given by:

$$\eta_t^H = 1 - 1/\sigma^H - \gamma_H \left[\beta(sfpE_t\pi_{t+1}^H + (1-sfp)\pi_{t-1}^H) - \pi_t^H\right] - u_t^H \qquad 0 \le sfp \le 1 \qquad (8)$$

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

3.2 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:

$$U(C_t^h, 1 - L_t^h, H_t^h) = \log\left(C_t^h - hC_{t-1}\right) + \vartheta\left(1 - L_t^h\right)^{1-\kappa} + \omega\log\left(H_t^h\right) \qquad (9)$$

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.

3.2.1 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:

$$
\begin{aligned}
&Max \quad V_0^r = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{rt} U(C_t^r, 1 - L_t^r, H_t^r) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{rt} \left(\begin{array}{l} (1+t_t^c) p_t^C C_t^r + \sum_j p_t^{K,j} (1 - itc_t) I_t^j + p_t^H (1+t_t^c) I_t^{H,r} + p_t^H (1+t_t^c) I_t^{HLC,r} + (B_t^{G,r} + B_t^r) \\ + rer_t B_t^{F,r} - (1+r_{t-1})(B_{t-1}^{G,r} + B_{t-1}^r) - (1+r_{t-1}^F)(1 - risk(.)) rer_t B_{t-1}^{F,r} \\ - \sum_j ((1-t_t^k) i_{t-1}^{K,j} + t_t \, \delta^{k,j}) p_{t-1}^{K,j} K_{t-1}^j - (1-t_t^W) w_t L_t^r + \frac{\gamma_W}{2} \frac{\Delta W_t^2}{W_{t-1}} - \\ ((1-t^k) i_{t-1}^H + \delta^H) p_t^H H_{t-1}^{LC,r} - p_t^L J_t^{Land} - \sum_{j=1} \mathrm{Pr}_t^j - \mathrm{Pr}_t^H + T_t^{LS,r} \end{array} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{rt} \left(\sum_j \xi_t^j (K_t^j - J_t^j - (1 - \delta^{K,j}) K_{t-1}^j) \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \zeta_t^r \beta^{rt} \left(H_t^r - J_t^{H,r} - (1 - \delta^H) H_{t-1}^{H,r} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \vartheta_t^r \beta^{rt} \left(H_t^{LC,r} - J_t^{HLC,r} - (1 - \delta^H) H_{t-1}^{LC,r} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \xi_t^r \beta^{rt} \left(Land_t + J_t^{Land} - (1 + g_t^L) Land_{t-1} \right)
\end{aligned} \tag{10}
$$

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:

$$I_t^j = J_t^j \left(1 + \frac{(\gamma_K^j + u_t^j)}{2} \left(\frac{J_t^j}{K_t^j} \right) \right) + \frac{\gamma_I^j}{2} (\Delta J_t^j)^2 \tag{11a}$$

$$I_t^{H,r} = J_t^{H,r} \left(1 + \frac{(\gamma_H + u_t^H)}{2} \left(\frac{J_t^{H,r}}{H_t^r} \right) \right) + \frac{\gamma_{IH}}{2} (\Delta J_t^{H,r})^2 \tag{11b}$$

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:

$$\frac{\mathrm{E}_t (C_{t+1}^r - hC_t)}{C_t^r - hC_{t-1}} = \beta^r (1 + r_t) \tag{12}$$

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

$$\left((\gamma_K^j + u_t^j)\left(\frac{J_t^{K,j}}{K_{t-1}^j}\right) + \gamma_I^j \Delta J_t^{K,j}\right) - E_t\left(\frac{1}{(1+r+\pi_{t+1}^{GDP} - \pi_{t+1}^{K,j})} \Delta J_{t+1}^{K,i}\right) = \frac{\xi_t^j}{p_t^K (1 - itc_t)} - 1 \tag{13}$$

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

$$\frac{\xi_t^j}{p_t^{K,j}} = \mathrm{E}_t\left(\frac{1}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^{K,j})} \frac{\xi_{t+1}^j}{p_{t+1}^{K,j}} (1-\delta^K)\right) + ((1-t_t^K) i_t^K + t_t^K \delta^{K,j}) = 0 \tag{14}$$

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

$$\left((\gamma_H + u_t^H)\left(\frac{J_t^{H,r}}{H_{t-1}^r}\right) + \gamma_{IH} \Delta J_t^{H,r}\right) - E_t\left(\frac{1}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^{H} - \Delta t_{t+1}^c)} \Delta J_{t+1}^{H,r}\right) = \frac{\zeta_t^r}{p_t^H (1+t_t^c)} - 1 \tag{15}$$

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:

$$\frac{\zeta_t^r}{p_t^H (1+t_t^c)} = \omega^r \frac{(C_t^r - hC_{t-1})(1+t_t^c) p_t^C}{H_t^r (1+t_t^c) p_t^H} + \mathrm{E}_t\left(\frac{1}{(1+r_t+\pi_{t+1}^{GDP} - \pi_{t+1}^{H} - \Delta t_{t+1}^c)} \frac{\zeta_{t+1}^r}{p_{t+1}^h (1+t_{t+1}^c)} (1-\delta^H)\right) \tag{16}$$

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

$$p_t^{Land} = \mathrm{E}_t\left(\frac{1}{(1+r_t)} p_{t+1}^{Land} (1+g_L)\right) \tag{17}$$

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 the price of land must be equal to $r_t - g_L$.

3.2.2 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:

$$\begin{aligned}
&Max \quad V_0^c = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{c\,t} U(C_t^c, 1 - L_t^c, H_t^c) \\
&-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{c\,t} \left((1+t_t^c) p_t^C C_t^c + p_t^H (1+t_t^H) I_t^{H,c} - B_t^c + (1+r_{t-1}) B_{t-1}^c - (1-t_t^W) w_t L_t^c + \frac{\gamma_W}{2} \frac{\Delta W_t^{\,2}}{W_{t-1}} + T_t^{LS,c}\right) \\
&-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \zeta_t^c \beta^{c\,t} \left(H_t^c - J_t^{H,c} - (1-\delta^H) H_{t-1}^c\right) \\
&-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t \beta^{c\,t} \left(B_t^c - (1-\chi) p_t^H H_t^c\right)
\end{aligned} \tag{18}$$

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

$$\frac{\mathrm{E}_t(C_{t+1}^c - hC_t)}{C_t^c - hC_{t-1}} = \beta^c \frac{(1+r_t)}{(1-\psi_t)} \tag{19}$$

and housing investment:

$$\left((\gamma_H + u_t^H)\left(\frac{J_t^{H,c}}{H_{t-1}^c}\right) + \gamma_{IH}\Delta J_t^{H,c}\right) - E_t\left(\frac{(1-\psi_t)}{(1+r_t+\pi_{t+1}^{GDP}-\pi_{t+1}^H-\Delta t_{t+1}^c)}\Delta J_{t+1}^{H,c}\right) = \frac{\zeta_t^c}{p_t^H(1+t_t^c)} - 1 \tag{20}$$

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:

$$\frac{\zeta_t^c}{p_t^H(1+t_t^c)} = \omega^c \frac{(C_t^c - hC_{t-1})(1+t_t^c)p_t^C}{H_t^c(1+t_t^c)p_t^H} + \psi_t(1-\chi) + \mathrm{E}_t\left(\frac{(1-\psi_t)}{(1+r_t+\pi_{t+1}^{GDP}-\pi_{t+1}^H-\Delta t_{t+1}^c)}\frac{\zeta_{t+1}^c}{p_{t+1}^H(1+t_{t+1}^c)}(1-\delta^H)\right) \tag{21}$$

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.

One specific feature in many of the Member States in Central and Eastern Europe is that many households are indebted in foreign currency. For example, it is estimated that in Latvia more than 90 per cent of mortgage debt is denominated in euros, while in Hungary household debt is predominantly in Swiss francs. Poland and Romania have similarly high shares of foreign currency denominated debt. To capture this feature we include an alternative specification of the budget constraint:

$$e_t B_t^c - (1+r_{t-1}^*)e_t B_{t-1}^c + (1-t_t^W)w_t L_t^c + TR_t^{LS,c} = (1+t_t^c)p_t^C C_t^c + p_t^H(1+t_t^H)I_t^{H,c} \tag{18'}$$

where B_t^c is now denominated in the foreign currency and *e* is the exchange rate (domestic currency per unit of foreign currency) and a star indicates foreign variables. The collateral constraint in this case takes the following form

$$e_t B_t^c = (1-\chi)p_t^H H_t^c \tag{18''}$$

3.2.3 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:

$$(1+t_t^c)P_t^c C_t^l = (1-t_t^w)W_t L_{tt}^l + TR_t^l - T_t^{LS,l} \tag{22}$$

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

3.2.4 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:

$$\frac{s^c U^c_{1-L,t} + s^r U^r_{1-L,t} + s^l U^l_{1-L,t}}{s^c U^c_{c,t} + s^r U^r_{c,t} + s^l U^l_{c,t}} = \frac{(1-t^W_t)}{(1+t^C_t)} \frac{W_t}{P^C_t} \eta^W_t \tag{23}$$

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:

$$\eta^W_t = 1 - 1/\theta - \gamma_W/\theta \left[\beta(\pi^W_{t+1} - (1-sfw)\pi_t) - (\pi^W_t - (1-sfw)\pi_{t-1}) \right] \qquad 0 \le sfw \le 1 \tag{24}$$

Combining (23) and (24) 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.

3.2.5 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:

$$C_t = s^r C^r_t + s^c C^c_t + s^l C^l_t \tag{25a}$$

and aggregate employment is given by:

$$L_t = s^r L^r_t + s^c L^c_t + s^l L^l_t \quad \text{with } L^r_t = L^c_t = L^l_t \tag{25b}$$

Since liquidity constrained households do not own financial assets we have $B^l_t = B^{lF}_t = K^l_t = 0$. Credit constrained households only engage in debt contracts with Ricardian households, therefore we have:

$$B^c_t = \frac{s^r}{s^c} B^r_t \tag{26}$$

3.3 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:

$$Z^i = \left[(1 - s^M - u_t^M)^{\frac{1}{\sigma^M}} Z^{d\,i\,\frac{\sigma^M - 1}{\sigma^M}} + (s^M + u_t^M)^{\frac{1}{\sigma^M}} Z^{f\,i\,\frac{\sigma^M - 1}{\sigma^M}} \right]^{\frac{\sigma^M}{(\sigma^M - 1)}} \tag{27a}$$

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:

$$Z^{d\,i} = \left[\sum_{h=1}^{n} \left(\frac{1}{n}\right)^{\frac{1}{\sigma^d}} Z_h^{d\,i\,\frac{\sigma^d - 1}{\sigma^d}} \right]^{\frac{\sigma^d}{\sigma^d - 1}}, \quad Z^{f\,i} = \left[\sum_{h=1}^{m} \left(\frac{1}{m}\right)^{\frac{1}{\sigma^f}} Z_h^{f\,i\,\frac{\sigma^f - 1}{\sigma^f}} \right]^{\frac{\sigma^f}{\sigma^f - 1}} \tag{27b}$$

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:

$$M_t = (s^M + u_t^M) \left[\rho^{PCPM} \frac{P_{t-1}^{\ C}}{P_{t-1}^{\ M}} + (1 - \rho^{PCPM}) \frac{P_t^C}{P_t^M} \right]^{\sigma^M} (C_t + I_t^{inp} + C_t^G + I_t^G) \tag{28}$$

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:

$$X_t = (s^{M,W} + u_t^X) \left(\rho^{PWPX} \frac{P_{t-1}^{\ C,F} E_{t-1}}{P_{t-1}^{\ X}} + (1 - \rho^{PWPX}) \frac{P_t^{C,F} E_t}{P_t^X} \right)^{\sigma^X} Y_t^F \tag{29}$$

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:

$$\eta_t^X P_t^X = P_t \tag{30}$$

and import prices are given by:

$$\eta_t^M P_t^M = E_t P_t^F \tag{31}$$

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 are also subject to random shocks:

$$\eta_t^k = 1 - 1/\sigma^k - \gamma_{Pk}\left[\beta(sfp^k \cdot_t \pi_{t+1}^k + (1-sfp^k)\pi_{t-1}^k) - \pi_t^k\right] + u_t^{P,k} \qquad k = \{X, M\} \tag{32}$$

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

$$E_t B_t^F = (1 + i_t^F) E_t B_{t-1}^F + P_t^X X_t - P_t^M M_t \tag{33}$$

3.4 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:

$$YGAP_t = \left(\frac{ucap_t}{ucap_t^{ss}}\right)^{(1-\alpha)} \left(\frac{L_t}{L_t^{ss}}\right)^{\alpha} \tag{34}$$

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

$$ucap_t^{ss} = (1 - \rho^{ucap}) ucap_{t-1}^{ss} + \rho^{ucap} ucap_t^j \tag{35}$$

$$L_t^{ss} = (1 - \rho^{Lss}) L_{t-1}^{ss} + \rho^{Lss} L_t \tag{36}$$

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:

$$\begin{aligned} i_t = {} & \tau_{lag}^{INOM} i_{t-1} + (1 - \tau_{lag}^{INOM})[r^{EQ} + \pi^T + \tau_{\pi}^{INOM}(\pi_t^C - \pi^T) + \tau_{y,1}^{INOM} ygap_{t-1}] \\ & + \tau_{y,2}^{INOM} ({}_t ygap_{t+1} - ygap_t) + u_t^{INOM} \end{aligned} \tag{37}$$

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.

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

$$B_t = (1+i_t) B_{t-1} + P_t^C C_t^G + P_t^C I_t^G + TR_t + itc_t P_t^I I_t - t_t^w W_t L_t - t_t^c P_t^c C_t - t_t^K i_t^K P_t^I K_{t-1} - T_t^{LS} \tag{38}$$

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

$$\Delta t_t^w = \tau^B \left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right) + \tau^{DEF} \Delta\left(\frac{B_t}{Y_t P_t}\right) \tag{39}$$

where b^T is the government debt target.

4 Model calibration

The model used in this exercise consists of six regions: the Euro area, the new member states not participating in the euro, the rest of the EU, the US, emerging Asia 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. Although the calibration incorporates some of the main stylised differences between the regions, it relies heavily on estimates of this model on euro area and US data (see Ratto *et al*., 2009a and 2009b). Table 2 summarises the main differences between the blocks, which are, for the EU countries, generally 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 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. However, our estimates suggest that the duration of wage spells in the US is similar to those in the EA. There are 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. Higher labour adjustment costs in the EU reflect higher employment protection in the EU. We assume similar capital adjustment costs in all regions. Concerning financial market frictions, we assume 30 percent of households to be liquidity-constrained, which corresponds closely to our estimates, and we keep this share unchanged. When we include collateral constrained households in the model we assume their share is 30 percent of households, and the remainder are all unconstrained "Ricardian" households (when for comparison in section 5 we exclude collateral constraints the share of Ricardian households is 70 percent). The loan-to-value ratio ($1-\chi$) is set at 0.75 in all regions, calibrated to fit a mortgage debt ratio as share of GDP on the baseline of around 50 percent. Estimated Taylor rules do not point to sizeable differences in monetary policy behaviour and we set these parameters identical. Other important stylised difference between regions are the size and generosity of the transfer system.

5 Fiscal instruments and their multipliers

There is no single fiscal multiplier but the size depends on a number of factors. Table 3 shows the fiscal multipliers of various fiscal instruments in 1) a model without collateral constraints, 2) in the model with collateral constrained households, and 3) in a model with collateral constrained households and with monetary accommodation. The multipliers reported in this table are for the EU as an aggregate region. Single country results will be somewhat smaller as the degree of openness of the economy also plays a significant role. In a small open economy more of the fiscal stimulus will leak abroad through higher imports. The duration is also important and the impact of a fiscal stimulus depends crucially on whether the shock is credibly temporary or perceived to be permanent. In the latter case, economic agents will anticipate higher tax liabilities and increase their savings, leading to stronger crowding out and smaller GDP effects. We only consider temporary fiscal stimulus here and focus on one year shocks of 1 per cent of baseline GDP.

In general, GDP effects are larger for public spending shocks (government consumption and

Table 2

Model Calibration

Item	EA	NE	REU	US	AS	RW
Nominal rigidities						
Avg. duration between price adjustments *(quarters)*	5.5	5.5	5.5	5	5	5
Avg. wage contract length *(quarters)*	4.5	4.5	4.5	4.5	4.5	4.5
Real rigidities						
Labour adjustment cost *(percent of total add. wage costs)* (γ_L)	13	13	13	10	10	10
Labour supply elasticity ($1/\kappa$)	1/5	1/5	1/5	1/3	1/3	1/3
Semi-wage elasticity w.r.t. employment rate (κ/γ_w)	0.33	0.33	0.33	0.20	0.20	0.20
Capital adjustment cost (γ_K)	20	20	20	20	20	20
Investment adjustment cost (γ_I)	75	75	75	75	75	75
Consumption						
Share of liquidity-constrained consumers s^l	0.3	0.3	0.3	0.3	0.3	0.3
Share of credit-constrained consumers s^c	0.3	0.3	0.3	0.3	0.3	0.3
Share of non-constrained consumers s^r	0.4	0.4	0.4	0.4	0.4	0.4
Downpayment rate χ	0.25	0.25	0.25	0.25	0.25	0.25
Habit persistence h	0.7	0.7	0.7	0.7	0.7	0.7
Monetary policy						
Lagged interest rate τ_{lag}^{INOM}	0.82	0.82	0.82	0.82	0.82	0.82
Consumer price inflation τ_{π}^{INOM}	1.5	1.5	1.5	1.5	1.5	1.5
Output gap τ_{Y}^{INOM}	0.05	0.05	0.05	0.05	0.05	0.05
National accounts						
Consumption	0.59	0.59	0.59	0.64	0.64	0.64
Investment tradedables	0.06	0.06	0.06	0.05	0.05	0.05
Investment non-tradables	0.07	0.07	0.07	0.06	0.06	0.06
Investment residential	0.06	0.06	0.06	0.06	0.06	0.06
Government consumption	0.18	0.18	0.18	0.15	0.15	0.15
Government investment	0.04	0.04	0.04	0.04	0.04	0.04
Exports	0.18	0.45	0.30	0.15	0.15	0.40
Imports	0.18	0.45	0.30	0.15	0.15	0.40
Transfers to households	0.16	0.16	0.16	0.13	0.13	0.13

investment) than for tax reductions and transfers to households. Increasing *investment subsidies* yields sizeable effects especially if it is temporary since it leads to a reallocation of investment spending into the period the purchase of new equipment and structures is subsidised. *Government investment* yields a somewhat larger GDP multiplier than *purchases of goods and services*. However, it is mainly the long run GDP multiplier which shows a significant difference because of the productivity enhancing effects of government investment. An increase in *government transfers* has a smaller multiplier, as it goes along with negative labour supply incentives. However, transfers targeted to liquidity constrained consumers provide a more powerful stimulus as these consumers have a larger marginal propensity to consume out of current net income.

Temporary reductions in *value added* and *labour taxes* show smaller multipliers, but in these cases it is nearly entirely generated by higher spending of the private sector. A temporary reduction in consumption taxes is more effective than a reduction in labour taxes as also forward looking households respond to this change in the intertemporal terms of trade.[5] A temporary reduction of taxes is attractive from a credibility point of view, since the private sector is likely to believe in a reversal of a temporary tax cut more than into a reversing of a temporary spending increase. Temporary *corporate tax* reduction would not yield positive short run GDP effects since firms calculate the tax burden from an investment project over its entire life cycle.

The presence of credit-constrained agents raises the multiplier as these agents have a larger marginal propensity to consume out of current net income. The multiplier increases especially for those fiscal measures which increase current income of households directly, such as labour taxes and transfers, while the increase is less strong for government consumption and investment. The reason for this is that credit constrained households not only have a higher marginal propensity to consume out of current income but their spending is also highly sensitive to changes in real interest rates (see Röger and in 't Veld, 2009). This is because the collateral constraint requires that spending must be adjusted to changes in interest payments. In other words, the interest rate exerts an income effect on spending of credit constrained households. For realistic magnitudes of indebtedness, the interest sensitivity exceeds the interest elasticity of spending of Ricardian households substantially.

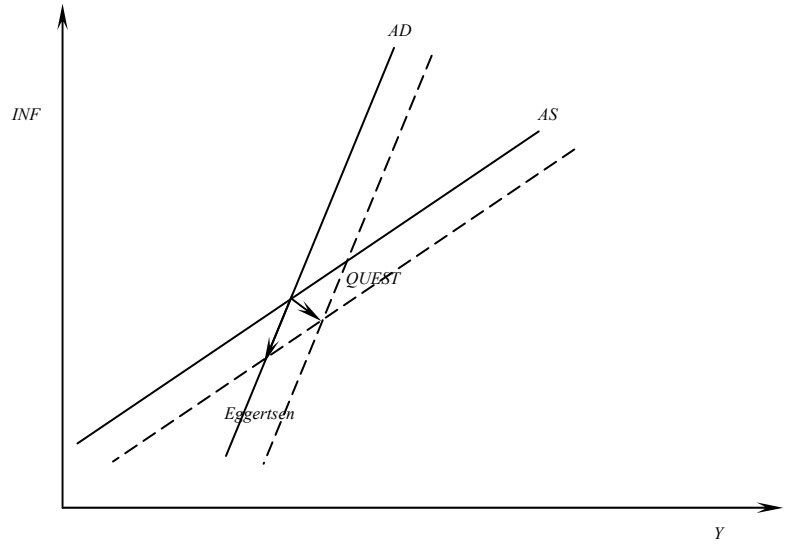
Fiscal policy multipliers become very much larger when the fiscal stimulus is accompanied by monetary accommodation. This is particularly relevant in the current crisis with interest rates at, or close to, their lower zero bound. Under normal circumstances a fiscal stimulus would put upward pressure on inflation and give rise to an increase in interest rates. With monetary accommodation and nominal interest rates held constant, higher inflation will lead to a decrease in real interest rates and this indirect monetary channel amplifies the GDP impact of the fiscal stimulus (Christiano *et al.*, 2009, Erceg and Linde, 2009). As shown in Röger and in 't Veld (2009), under monetary accommodation, both spending and tax multipliers are considerably larger and this effect is amplified in the presence of credit constrained households. For the case where nominal interest rates are kept constant for four quarters, the government consumption multiplier increases by about 40 per cent with collateral constrained households, while it would only increase by about 10 per cent without credit constraints. The latter increase of the multiplier is similar to the change of multiplier obtained by Christiano *et al.* (2009) for the same experiment. This amplification effect of the zero bound multiplier with credit constraints is again due to the strong response of spending of credit constrained households to changes in real interest rates.

The zero bound increases the multiplier substantially for all expenditure and revenue categories, except for labour taxes, where the increase in the multiplier is insignificant. This can easily be explained by the fact that a central mechanism which increases the expenditure multiplier

[5] Note that this assumes the VAT reduction is fully passed through into consumer prices. This intertemporal effect will be strongest in the period just before taxes are raised again (in t+1).

Figure 1

The Effect of Cutting Taxes at the Zero Bound



at the zero bound, namely an increase in inflation is likely not be present in this case, or is even reversed because a reduction in labour taxes will at least partly be shifted onto firms and thus will end up in lower prices. Nevertheless, this result is in sharp contrast to a result obtained by Eggertson (2009), who claims that the labour tax multiplier at the zero bound will be negative. His argument is based on the assumption that a labour tax reduction will only shift the aggregate supply (AS) curve to the right in the inflation-GDP space, while the aggregate demand (AD)curve does not shift and is upward sloping in the case of a zero bound. In contrast to this analysis, in the QUEST model there is also a shift of aggregate demand associated with a tax cut (see Figure 1).

There are at least three important sources for such a shift and two of them are not present in Eggertson's model. First, there is a international competitiveness effect as a result of declining costs, which increases net external demand. Second, there is a shift in corporate investment because of an increase in the marginal product of existing capital because of an increase in employment. Both of them are not present in Eggertson's model. However, a tax reduction also shifts consumer spending either via higher net labour income or higher employment a combination of which must necessarily result from a labour tax cut. These three demand effects taken together make it unlikely that the labour tax multiplier turns negative at the zero bound.

Finally, there are also sizeable positive *spill-over effects* from fiscal stimuli. The effects of a global fiscal stimulus (as in the final three columns in Table 1) are larger than when the EU acts alone. In the current crisis there has been a global fiscal stimulus with large fiscal packages implemented in all G20 countries, and model simulations suggest this resulted in larger multipliers.[6]

The table also indicates the costs of a withdrawal of a stimulus. These also depend on the presence of collateral constraints and on monetary policy accommodation. As long as credit conditions remain tight, and more households face a binding collateral constraint on their borrowing, the larger the costs of a withdrawal of fiscal stimulus. Second, as long as interest rates remain low, monetary policy is less likely to support a fiscal tightening by reducing interest rates. An early withdrawal of fiscal stimulus risks a much sharper contraction in output than when the exit is delayed till monetary conditions have returned to normal.

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[6] In the Annex we provide an assessment of the fiscal stimulus measures by member states for 2009 and 2010, as outlined in Section 2, and calculate the estimated GDP impact according to these multipliers depending on whether the stimulus is temporary or permanent (in the latter case multipliers are lower, see Röger and in 't Veld, 2009), and depending on whether the stimulus is accompanied by monetary accommodation.

Table 3

Fiscal Multipliers

Item	EU Alone			Global Stimulus		
	Without Collat. Constr.	**With Collat. Constr.**	**With Collat. Constr. + Mon. Acc.**	**Without Collat. Constr.**	**With Collat. Constr.**	**With Collat. Constr. + Mon. Acc.**
Investment subsidies	1.29	1.36	2.1	1.8	1.93	2.65
Government investment	0.87	0.89	1.22	1.04	1.07	1.33
Government consumption	0.75	0.77	1.17	0.93	0.98	1.33
General transfers	0.18	0.38	0.59	0.23	0.49	0.65
Transfers targetted to collateral constrained hh.	-	0.63	0.98	-	0.81	1.08
Transfers targetted to liquidity constrained hh.	0.63	0.66	1.02	0.79	0.84	1.12
Labour tax	0.23	0.41	0.47	0.26	0.48	0.52
Consumption tax	0.44	0.5	0.76	0.54	0.64	0.84
Corporate income tax	0.02	0.02	0.03	0.03	0.03	0.04

Note: Effect on EU GDP (percent diff. from baseline) for a temporary one year fiscal stimulus of 1 per cent of baseline GDP.

6 Simulations of fiscal stimulus in a credit crunch

The global recession has hit the various Member States of the European Union to different degrees. Ireland, the Baltic countries, Hungary and Germany have seen the sharpest contractions, while Poland seems to have been the only country that has so far escaped an outright recession (but has also suffered a sharp slowdown in GDP growth). The financial crisis was initially driven by sharp declines in house and asset prices and a tightening of credit conditions. The extent to which the crisis has been affecting the individual Member States of the European Union strongly depends on their initial conditions and the associated vulnerabilities.[7] In particular the role of overvalued housing markets and oversized construction industries is important. Strong real house price increases have been observed in the past ten years or so in the Baltic countries, and in some cases this has been associated with buoyant construction activity. The greater the dependency of the economy on housing activity, including the dependency on wealth effects of house price increases on consumption, the greater the sensitivity of domestic demand to the financial market shock. Some Member States in Central and Eastern Europe have been particularly hard hit through this wealth channel, notably the Baltic countries.

In order to illustrate the role of fiscal policy in this crisis, we first create a "recession scenario". This credit crunch scenario is driven by a combination of domestic shocks, existing of a reduction in the loan to value ratio and shocks to arbitrage equations which explain business fixed investment and residential investment (Q-equations) that capture the bursting of a bubble in these asset prices. These shocks to arbitrage equations can be interpreted as non-fundamental shocks or as "bubbles", as they are shocks to the optimality conditions for investment and house prices. As a declining risk premium in the Q equation for investment indicates the building up of a bubble, a

[7] For a discussion, see European Economy (2009), Economic Crisis in Europe: causes, consequences and responses.

rapid rise in the risk premium indicates the bursting of a bubble. The shocks start in 2008Q1 and are calibrated such that GDP falls by about 2 per cent in 2009.[8]

Figure 2 shows the profile for GDP and the main macroeconomic components, both in the case of debt denominated in domestic currency as well as the case when debt is denominated in foreign currency. The shocks lead to sharp declines in corporate investment and in consumption and residential investment of in particular collateral constrained households. When household debt is denominated in foreign currency, the further tightening of the collateral constraint caused by the depreciation (for new member states *vis-à-vis* the euro) leads to an even sharper decline in spending by these constrained households, even though the depreciation is relatively small. This negative effect on domestic demand is stronger than the boost given to export growth from the devaluation and the decline in GDP is larger. The shocks have a negative impact on tax revenues and raise unemployment benefit spending, leading to an increase in government deficits and debt.

We can now illustrate what fiscal policy can do to mitigate the output losses of this "crisis" scenario. Figure 3 shows the effect of fiscal stimulus measures in this recession scenario. In order to avoid unnecessary duplication, we only show here results for the NE block in the model, representing the Member States in Central and Eastern Europe, and assume household debt is denominated in foreign currencies (euros). The results for the other regional blocks in the model are comparable. We consider first a one year increase in government consumption of 1 per cent of GDP. The stimulus starts in 2009q1 and is announced as a one year shock which is believed to be credible. As the NE block in the model representing the New Member States in Central and Eastern Europe is a smaller and more open economy than the EU aggregate block for which multipliers are reported in Table 2, the fiscal multiplier is significantly smaller here (0.57 compared to 0.77). Nevertheless, the fiscal stimulus helps to cushion the impact of the recession and boost output at least for the duration of the year of the stimulus. In the following year, output falls to slightly below where it would have been in the pre-stimulus recession scenario. The temporary fiscal stimulus worsens the government budget balance and raises the debt-to-GDP ratio further.

Fiscal multipliers are considerably larger when interest rates are near their zero bound as monetary policy can then accommodate the fiscal stimulus by keeping nominal interest rates unchanged and allowing real interest rates to fall due to the increase in inflationary pressures. Monetary policy in the euro area has been able to accommodate the fiscal impulse in this way but in many of the new member states monetary policy has not been able to play this supportive role as interest rates have remained (with the exception of the countries in the euro area – Slovenia and Slovakia). Figure 4 shows the much larger effects when monetary policy can accommodate the fiscal stimulus. Note that the higher growth impact also helps to lessen the impact on government deficits and debt.

While temporary fiscal stimulus can be effective in supporting output in the short run, a more prolonged stimulus package lasting many more years does not become more powerful. Collateral constrained consumers react strongly to temporary increase in disposable income, but react more like Ricardian households to permanent income shocks, smoothing their income intertemporally.[9] Figure 5 shows the impact of a more prolonged stimulus lasting for three years and then gradually phased out. The impact of this stimulus in the first quarter of the expansion is actually smaller then the impact of a one year stimulus and output falls in the medium term to a lower level. The government deficit now increases for a duration of more than 3 years, and the debt-to-GDP ratio increases by an additional 3 percentage points.

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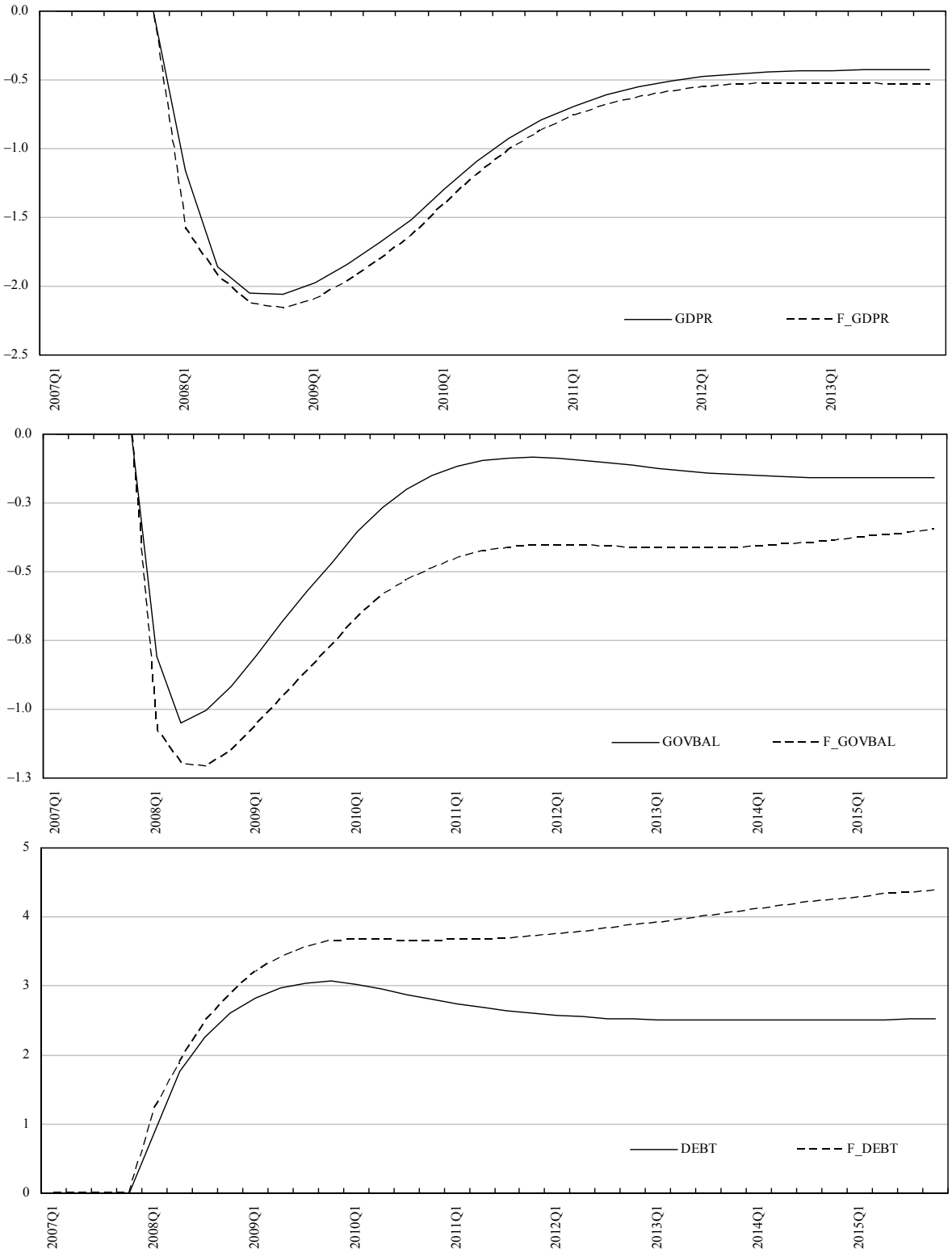
[8] This scenario merely serves as an illustrative baseline against which to show the effects of fiscal policy stimulus, and the scenario is a relatively mild recession, where the slowdown in growth is dampened by higher exports growth due to the depreciating currency. The sharp fall in world growth in 2009 which prevented this cushioning channel from operating is not simulated here.

[9] The differences between temporary and permanent fiscal shocks are shown in Röger and in 't Veld (2009).

Figure 2

Domestic Credit Crunch Scenario: GDP, Deficit/GDP Ratio, Debt/GDP Ratio



Note: GDP percentage difference from baseline, Govbal and debt as percent of GDP.
Dashed line F_: debt denominated in foreign currency.

Figure 3

Temporary Fiscal Expansion

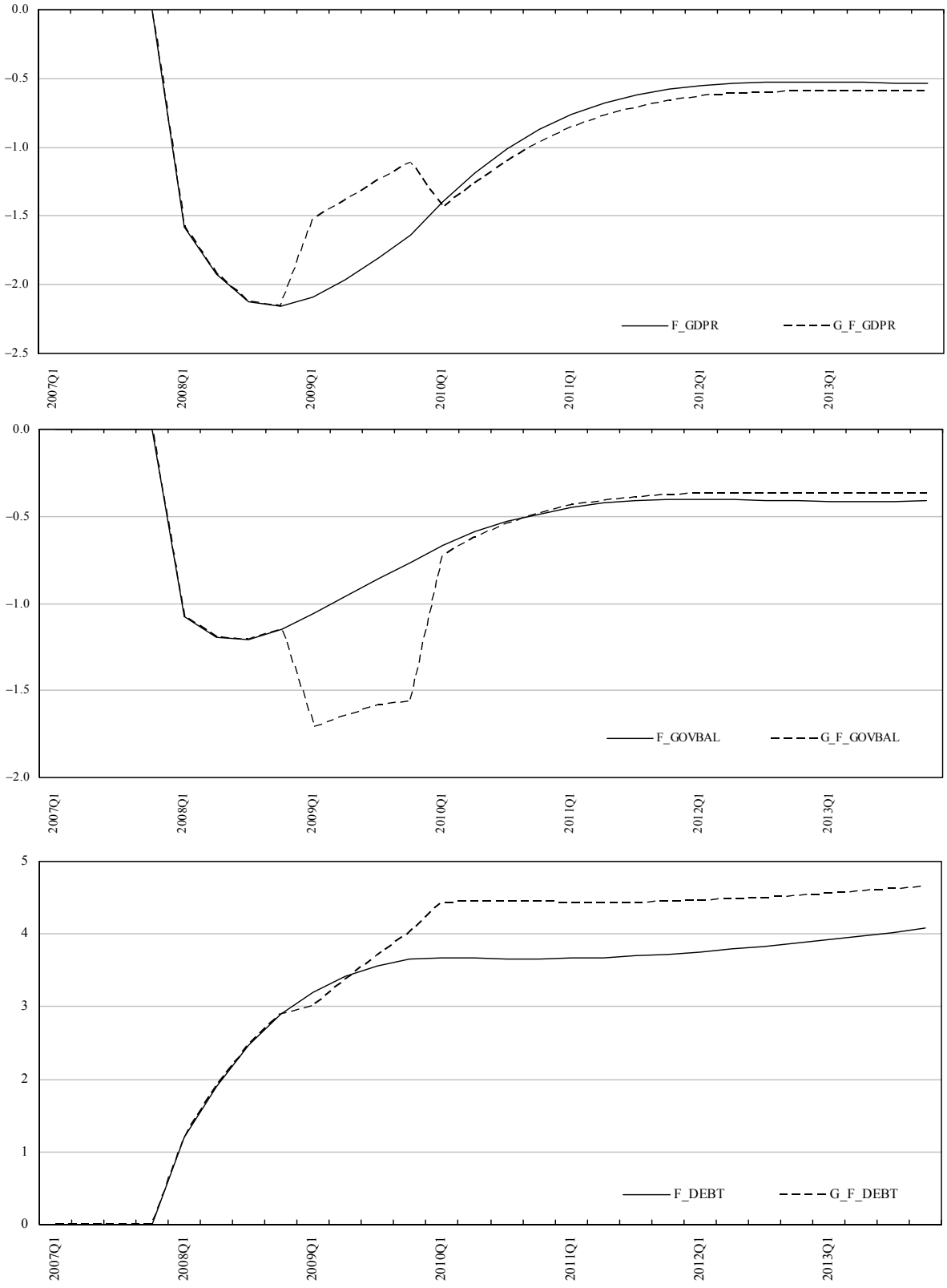


Figure 4

Temporary Fiscal Expansion with Monetary Accommodation

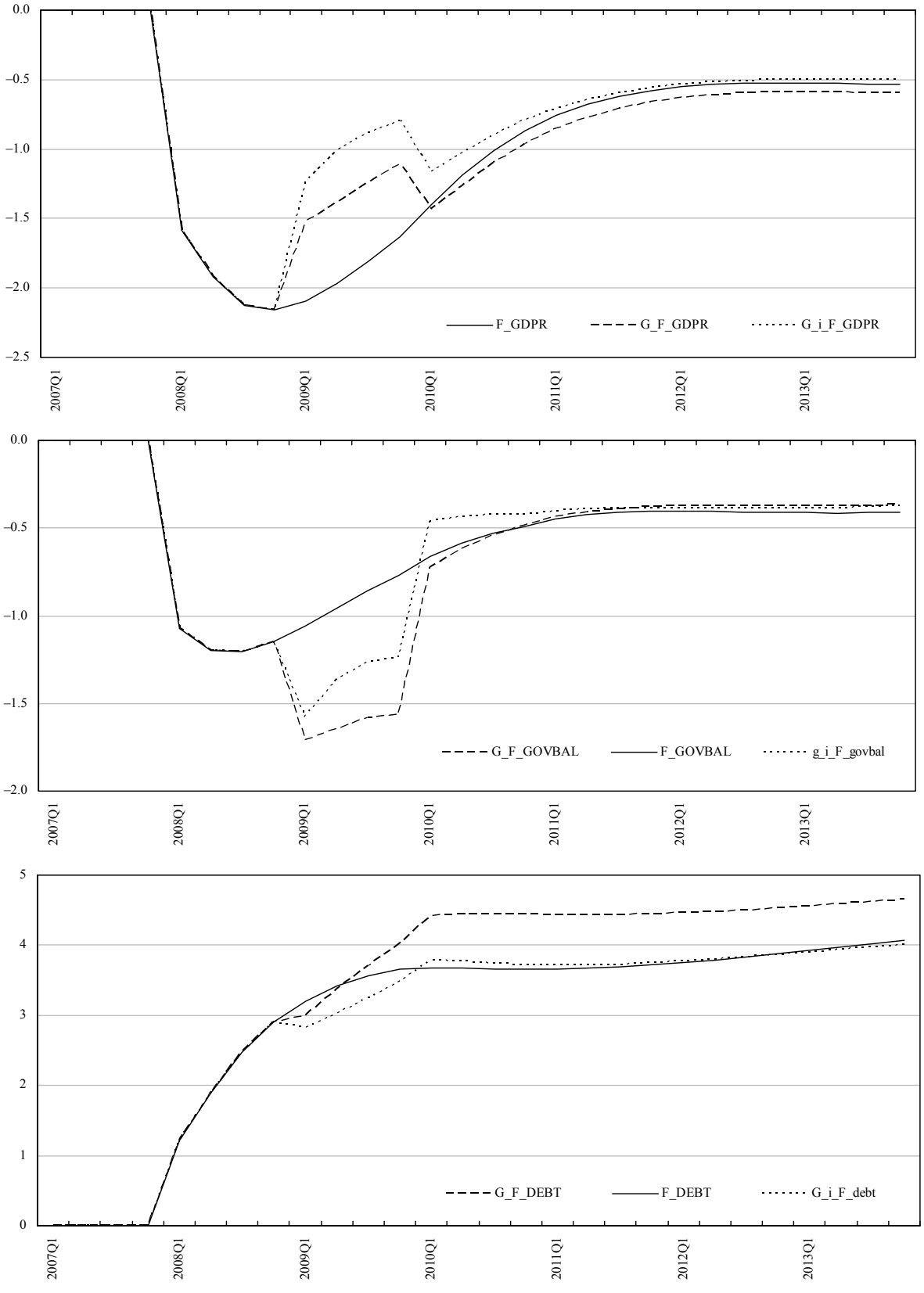
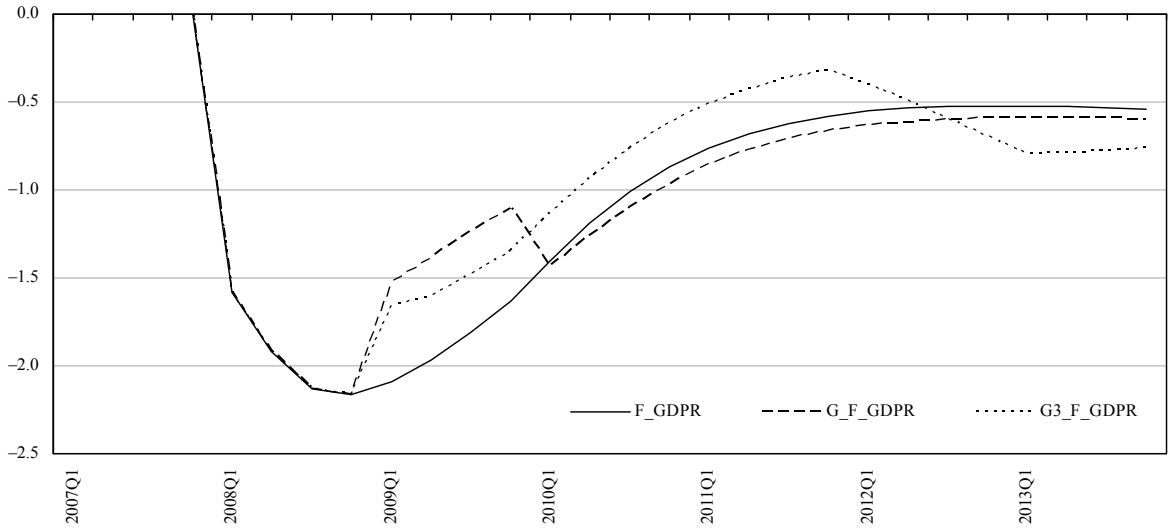
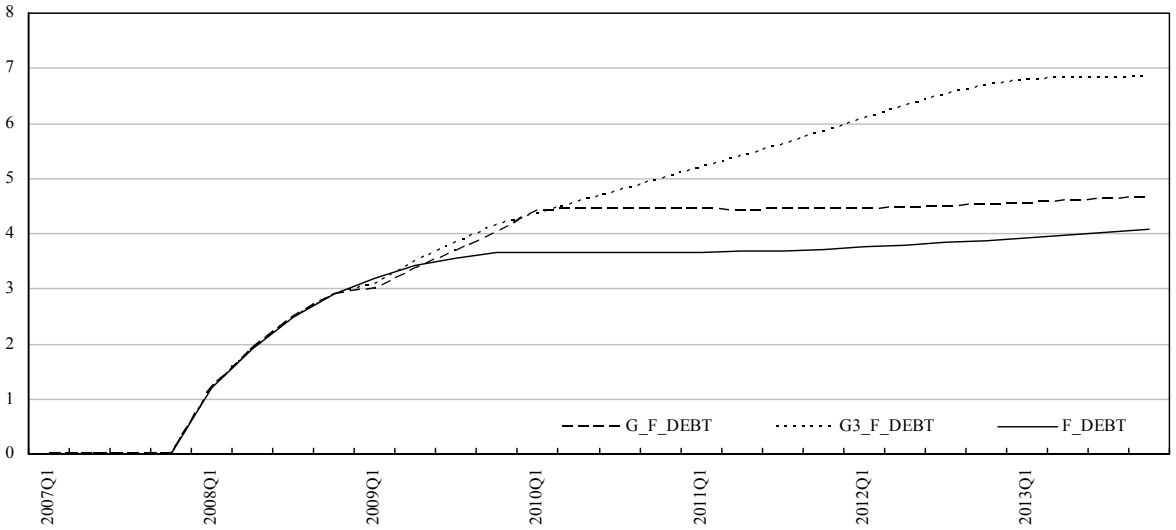


Figure 5

Temporary vs. Prolonged Fiscal Expansion





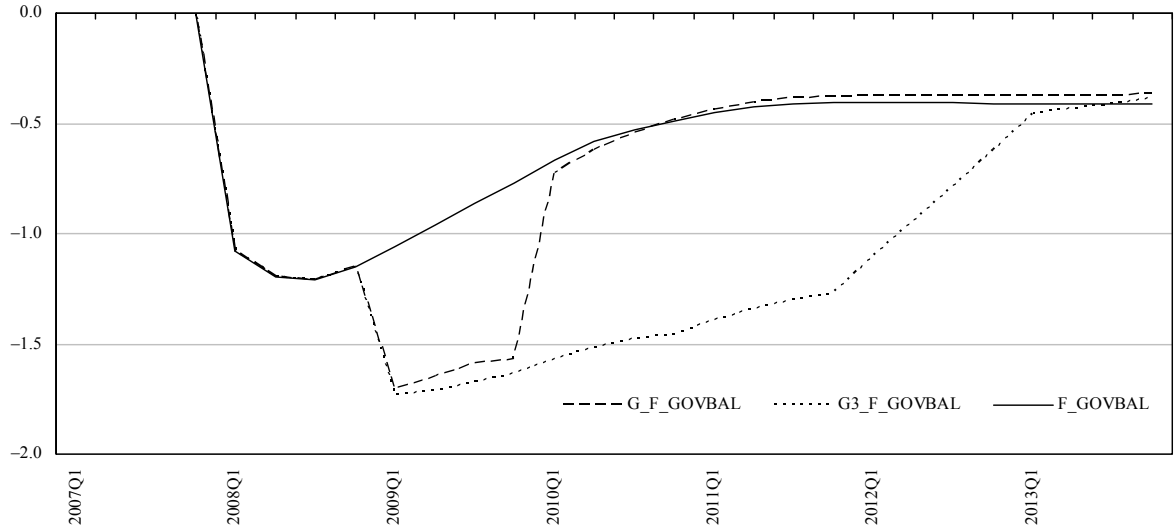
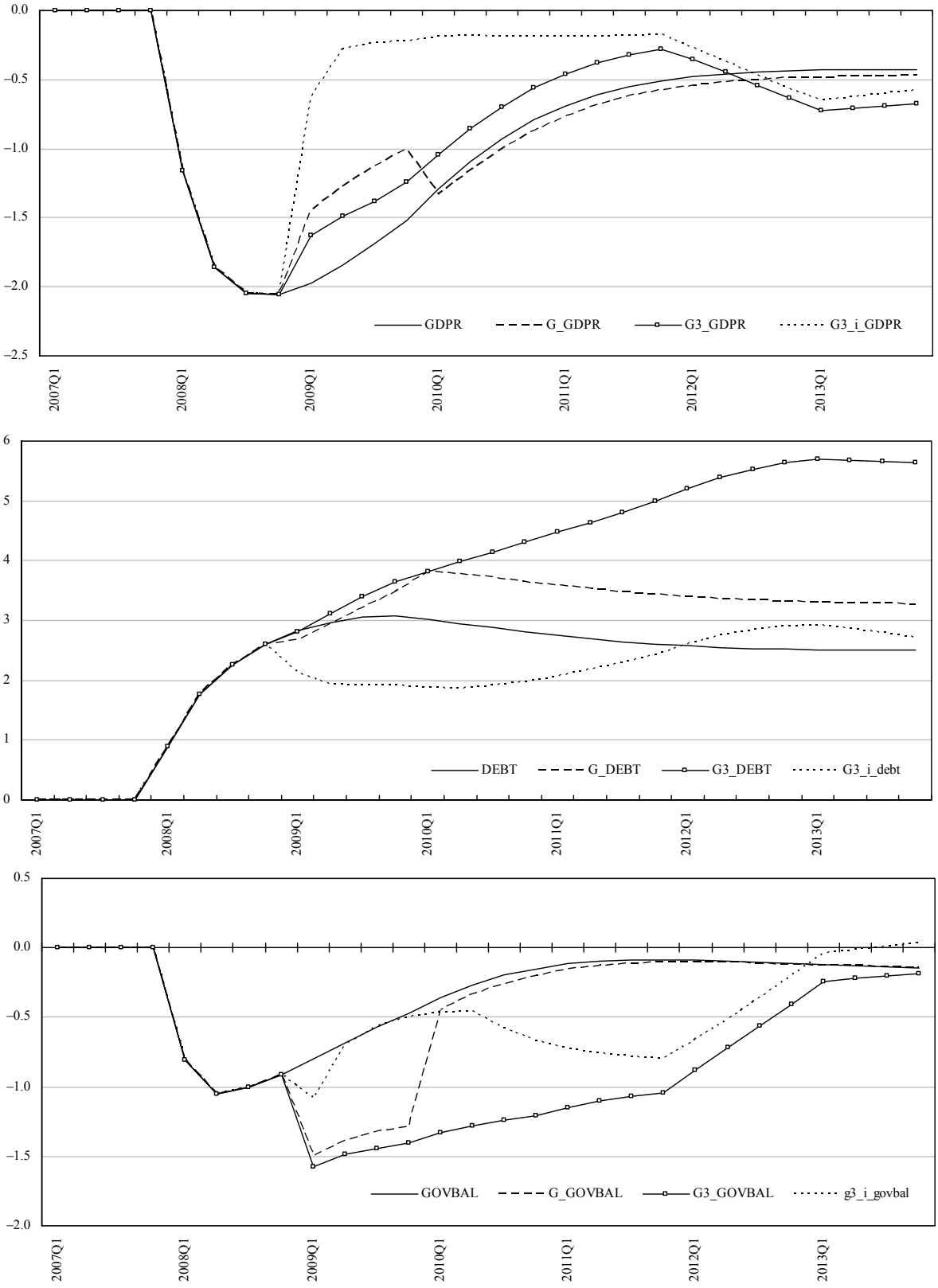


Figure 6

Temporary vs. Persistent Fiscal Expansion with Monetary Accommodation



However, a longer lasting fiscal stimulus can be significantly more effective if it is accompanied by an accommodative monetary policy. Figure 6 shows the results for this case, when nominal interest rates are kept unchanged. As the fiscal stimulus is longer lasting, more inflationary pressures build up and with unchanged nominal interest rates, real interest rates decline by more. This additional real interest rate effect has a strong impact on output and the combination of the fiscal and monetary stimulus helps to almost offset the effect of the credit crunch shocks. This real interest rate channel is effective in the euro area and the US, where interest rates are at or close to their lower zero bound, and central banks can keep nominal interest rates unchanged. Note also that at least in the short run the strong growth effects in this scenario also help to reduce the deterioration in government balances.

7 Conclusions

The paper has described a DSGE model with collateral constrained households and housing investment and used this to examine the effectiveness of fiscal stimulus measures in a credit crisis. The financial accelerator mechanism in the model allows it to be used for an analysis of falling asset prices and tightening credit conditions on the economy. The presence of credit constrained households and the fact that the zero lower bound on nominal interest rates became binding in the crisis, meant that fiscal multipliers were higher than in normal circumstances.

While the above suggests a larger role for fiscal policy in the euro area, in many of the Member States in Central and Eastern Europe interest rates were generally higher. As it is less likely that monetary policy in these countries can accommodate the fiscal impulse, fiscal policy is less effective than in countries where nominal interest rates can be kept unchanged and real interest rates are allowed to fall. However, even when monetary policy cannot accommodate the fiscal impulse, well-designed fiscal stimulus measures can still help to soften the impact of the crisis and mitigate the detrimental effects on (potential) growth.

A further analysis should shed light on the appropriate exit strategy. As noted, many of the countries most affected by the crisis, particularly among the new Member States, have had very limited room to implement stimulus measures. To the contrary, they often have predominantly adopted consolidation measures with a view to avoiding a further fall-out from the crisis. How such consolidation efforts are best designed according the DSGE modelling framework used in this paper, would be the subject of future research.

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