Pegging or Joining the Euro - Sudden Stops and Current Account Dynamics

Abstract

The ongoing discussion whether the financial crisis was followed by a balance-of-payment crisis or a fiscal crisis reached its temporary peak with the debate on settlements of intra-Eurosystem payments via TARGET2. Looking at current account adjustments after the crisis, there has been a considerable decrease of private capital inflows into countries that are pegged to the Euro and Euro area member countries. In fact, private capital was replaced by public capital in EMU countries maintaining current account deficits. We estimate a small open economy model with nominal wage and price rigidities using 2003Q1-2015Q4 data for the group of Greece, Ireland, Portugal (EMU peripheral countries) and the group of Bulgaria, Estland, Lithuania, and Latvia (pegged to the Euro) in order to analyze the differences in the adjustment process. We find that intra-Eurosystem payments helped to maintain output, consumption and investment on a relative high level during the financial crisis. The group of countries pegged to the Euro experienced a sharp decline in the respective variables during and a quick adjustment in the aftermath of the financial crisis, accompanied by a stable level of government debt. Our analysis further determines TFP and risk premium shocks as main drivers of the endogenous variables. Additionally, EMU member countries suffer from consumption shocks, whereas countries outside Euro are more exposed to credit constraint shocks. The findings support the significance of sudden stops for countries pegged to the Euro as well as the dependence of EMU peripheral countries from intra-Eurosystem payments.

1 Introduction

Since the financial crisis and the subsequent 'sudden stop', specific attention has been given to international capital flows, mainly concerning European Member Union (EMU) peripheral countries. Regardless whether the reversal of capital flows came into existence out of a balance of payment crisis or a failure in the initial institutional design, the respective countries had to undergo an adjustment process in current account (Febrero et al., 2016). Aside from EMU peripheral countries like Greece, Ireland, Portugal (GIP), sudden stops were also relevant for countries that pegged their currency to the Euro like Bulgaria as well as the Baltic States Estonia, Latvia and Lithuania (=BELL). However, the adjustment process of those countries was more severe on impact and faster in terms of current account re-balancing than for EMU peripheral countries (Gros and Alcidi, 2014). Despite the common lack of exchange rate adjustment after a shock, the two groups of countries differ substantially in the recovery of macroeconomic variables, such as Gross Domestic Product (GDP), consumption, and current account. According to Gros and Alcidi (2014), one reason for the sharp decline in current account of BELL is that private capital inflows dried up rapidly after the crisis, whereas private capital flows were replaced by public capital flows into GIP leading to a rather smooth decline in current account. Against this background, it is of particular interest to analyze cross-country differences in the adjustment to the drying up of capital inflows into a country inside versus outside of EMU.

In this paper, we first simulate a sudden stop in capital inflows for peripheral countries inside and outside EMU by using a small open economy DSGE model with financial frictions suggested by recent literature on collateral constraints tied to the housing sector (e.g Roeger and in 't Veld, 2009; Iacoviello, 2005; Iacoviello and Neri, 2010). We depart from this approach by directly relating credit constraints to net borrowings from the foreign economy, in order to focus on the isolated effect of sudden stops. In a second step, we augment our model with additional public capital flows (TARGET2 balances) that replaces private capital flows into the country when the credit constraint binds. In order to take account for the differences in the adjustment process to a sudden stop, this paper estimates the model for data of BELL as well as GIP, evaluates the historical shock decomposition of endogenous variables, and describes the Bayesian impulse responses of selected variables and shocks.

The literature on financial frictions and sudden stops mainly coexists with a large body of literature on financial crisis (e.g. Mendoza, 2010; Ozkan and Unsal, 2010). Empirical studies confirm periods of large private capital inflows followed by sharp reversal in capital flows, referred to as sudden stops, and large drops in domestic output (e.g. Reinhart and Calvo, 2000; Calvo et al., 2006; Mendoza and Terrones, 2008; Merler and Pisani-Ferry, 2012). This view is supported by Mendoza (2010) who includes an occasionally binding collateral constraint into an equilibrium business cycle model and finds a negative impact on output amplified by a decline in domestic asset prices. Merler and Pisani-Ferry (2012) find evidence of private capital replaced by public capital in form of TARGET2, highlighted in intra-Eurosystem net balances. Based on Mendoza (2010), Fagan and McNelis (2014) augment a calibrated model with TARGET financing by relating TARGET2 balances with interest rate spreads. The authors provide an additional welfare analysis that suggests small welfare gains due to the effects of precautionary savings.

Regarding the existing literature, this paper contributes in two main dimensions by (i) modeling sudden stops of private capital inflows into a small open economy that is either pegged to the Euro without intra-Eurosystem payments or an EMU peripheral country with public capital assistance as private capital replacement (ii) estimating the model for two representative groups of countries, namely GIP and BELL. We compare the estimated parameter results of the group of countries inside EMU with those pegged to EMU.

The analytical framework is a small open economy DSGE model according to Gali and Monacelli (2008). The focus on a small EMU member country (or pegged to it) excludes feedback effects from domestic events to monetary policy and (the rest of) Monetary Union. This is particularly relevant for analyzing open economies, which tend to be more exposed to asymmetric shocks. Due to our small open economy assumption, this paper widely excludes from potential spillover effects on (the rest of) Monetary Union.

The study finds that intra-Eurosystem payments in form of TARGET2 helped to maintain output, consumption, and investment during the financial crisis relative to countries outside EMU that were also exposed to a sudden stop of private capital but isolated from additional public capital flows. However, EMU member countries experienced a more prolonged adjustment process in the aftermath of the crisis. In the estimation for the group of Greece, Ireland, and Portugal (EMU peripheral countries), as well as the group of Bulgaria, Estonia, Latvia and Lithuania (pegged to the Euro), we obtain sizable and significant estimates for key parameters in the model which support the argumentation.

The remainder of the paper proceeds as follows: In Section 2, we describe the theoretical model. Section 3 outlines the estimation strategy, a description of the data and an overview of the posterior mean for the estimated parameters. In order to explain the effects of a binding collateral constraint, Section 4 shows simulations of a negative economy-wide productivity (TFP) and risk premium shock. Negative TFP and risk premium shocks are used as reference shocks that cause negative net foreign asset (NFA) positions. After Section 4 explains the basic relationships in the model, the results of the estimation in form of a historical shock decomposition as well as Bayesian impulse response functions of selected endogenous variables can be found in Section 5. In order to provide consistency to the simulation as well as the historical shock decomposition, Section 5 concentrates on TFP and risk premium shocks. Section 6 concludes.

2 The Model

The small open economy model is based on Hohberger et al. (2014). It consists of two sectors (tradable and non-tradable), two input factors, and includes nominal as well as real frictions. Households are distinguished between liquidity constrained households (LC) which do not have access to financial markets, but consume their entire current disposable wage in each period and Ricardian (NLC) households which have full access to financial markets and are able to smooth consumption over time. We analyze the effects of a sudden stop for a small open economy inside versus a small open economy outside the Euro area but pegged to its currency. Therefore, we include a credit constraint on NFA positions for NLC households following Roeger and in 't Veld (2009) and compare the effects of a binding credit constraint (BELL case) to the effects when the inflow of private capital is replaced by public capital flows (TARGET2). In both cases, the economy experiences a sudden stop of private capital inflows. TARGET2 ensures a further increase in NFA positions (GIP case). Following Schmitt-Grohe and Uribe (2003), this model uses a debt dependent country risk premium on foreign asset holdings as external closure. It allows for introducing risk premium shocks that directly affect nominal interest rate differentials and serves as a way to mimic demand booms by lowering borrowing costs. Goods markets are imperfectly integrated across borders in the sense that there is home bias in the demand for goods. Labor is immobile between countries. The foreign economy (rest of Monetary Union) variables and monetary policy are exogenously given from the perspective of the small economy. In the case of BELL, we depart from this assumption and consider a small open economy outside monetary union, i.e. with monetary policy independence (Taylor-type monetary policy rule) which is, however, pegged to the Euro with a nominal exchange rate peg. For the sake of brevity, this section only displays the main equations of the model setting. The detailed description of the model can be found in Hohberger et al. (2014). Fig. 1 summarizes the model structure.

Households

Household utility is additive in consumption C_t^i and work L_t^i. As utility has a constant risk aversion σ, the elasticity of intertemporal substitution is given by $1/\sigma$, κ specifies the weight on the disutility of work, and $1/\varphi$ stands for the elasticity of labour supply.

For NLC households, who are a fraction $(1-slc)$ of the population, the intertemporal

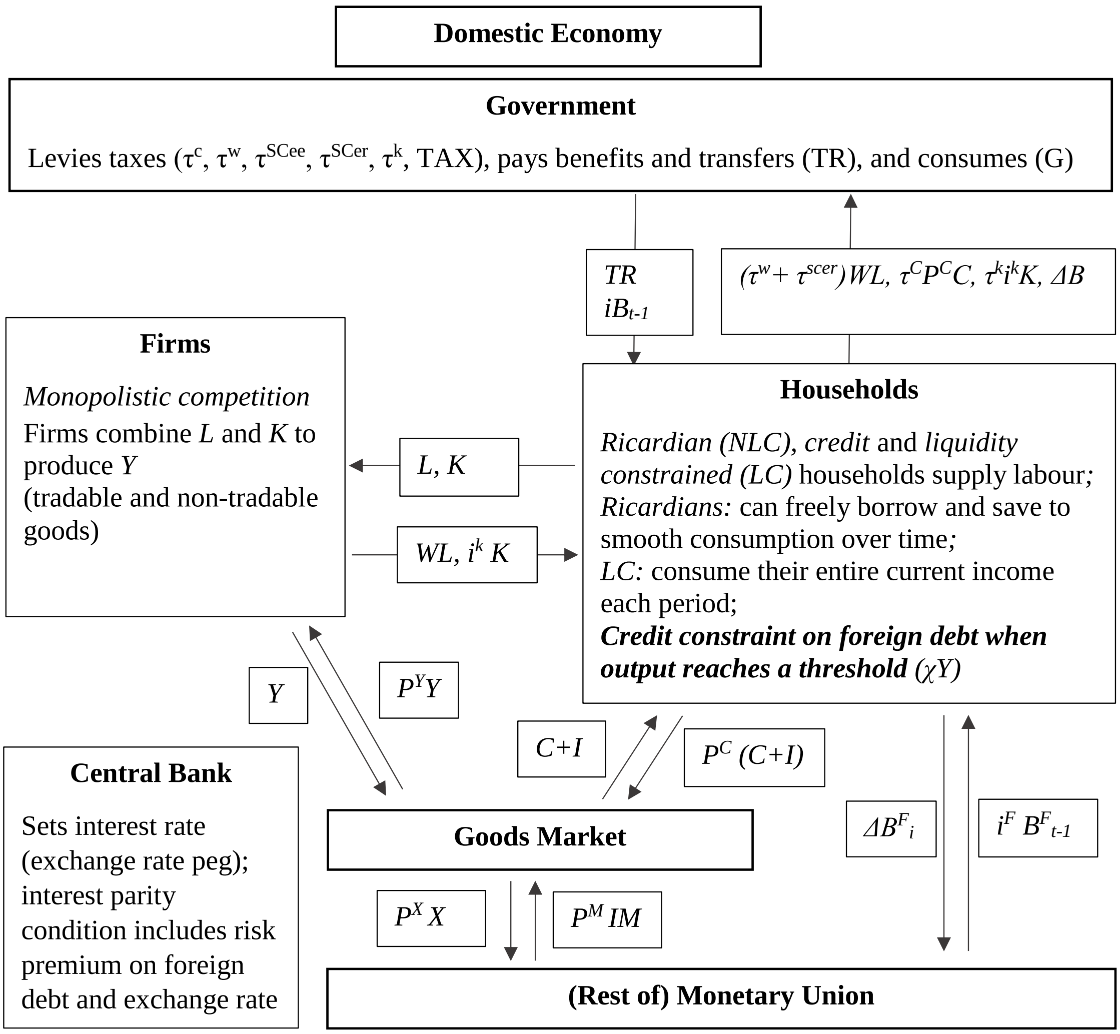

Figure 1: Model strucutre

budget constraint is:

$$
\begin{aligned}
&(1-\tau_t^w-\tau_t^{SCee})W_t^i L_t^i + (1+i_{t-1})B_{t-1} + (1+i_{t-1}^* - \omega\frac{B_{H,t-1}^*}{4P_{t-1}^Y Y_{t-1}} + \epsilon_t^r)B_{t-1}^* + \\
&TR_t + (1-\tau_t^k)i_t^k K_{t-1}^i + \tau_t^k \gamma P_t^C K_{t-1}^i + PR_t \\
&= (1+\tau_t^C)P_t^C C_t^N LC + P_t^C I_t^i + B_t + B_{H,t}^* + \gamma_w/2(\pi_t^{w,i})^2 P_t^C L_t + TAX_t.
\end{aligned}
\tag{1}
$$

The revenue side includes net nominal wage income $(1-\tau_t^w-\tau_t^{SCee})W_t^i$ adjusted by

labour tax and social contribution costs, the payment on maturing one-period domestic government bonds B_{t-1} including interest i_{t-1}, the repayment of one-period net foreign assets $B^*_{H,t-1}$ including interest i^*_{t-1} and the endogenous part of the risk premium $-\omega \frac{B^*_{H,t-1}}{4P^Y_{t-1}Y_{t-1}}$ and the exogenous component ϵ^r_t, lump-sum transfers from the government TR_t, the return to capital $(1-\tau^k_t)i^k_t K^i_{t-1}$ net of capital taxes and depreciation allowances and profit income from firm ownership PR_t. The expenditure side combines nominal consumption including taxes $P^C_t C^N_t LC$, nominal investment in the tradable and non-tradable sector $P^C_t I^i_t$, financial investment in domestic bonds and net foreign assets, quadratic adjustment costs γ_w for wages ($\pi^{w,i}_t = W^i_t / W^i_{t-1} - 1$) and the non-distortionary lump-sum tax TAX_t.
Additionally, Ricardian households face a credit constraint $(1-\chi)$ that binds after negative NFA positions exceed a certain share of GDP. The following constraint prevents the domestic economy from refinancing on international capital markets:

$$B_t - (1-\chi)P^Y_t Y_t = 0.^1 \tag{2}$$

The optimal consumption path for NLC households is given by:

$$\beta E_t\left(\frac{1+\tau^C_t}{1+\tau^C_{t+1}} \frac{P^C_t}{P^C_{t+1}} \left(\frac{C^{NLC}_t}{C^{NLC}_{t+1}}\right)^{\sigma}\right) = \frac{1-\psi}{1+i_t}. \tag{3}$$

where ψ is the Lagrange multiplier on the collateral constraint for the NFA position and acts like a risk premium on interest rate (see Roeger and in't Veld, 2009).
The interest parity condition

$$i_t = i^*_t - \frac{E_{t+1}}{E_t} - \omega \frac{B^*_{H,t-1}}{4P^Y_{t-1}Y_{t-1}} + \epsilon^r_t \tag{4}$$

includes the risk premium with $\omega > 0$ and ϵ^r_t as an exogenous AR(1) risk premium shock. LC households account for the share *slc* of the population. Their period

[1] In the case of GIP, a public capital flow is added to the equation maintaining negative NFA positions. Public capital flows are captured in the estimation part by TARGET2 data for the respective countries.

budget constrained is:

$$(1-\tau_t^w-\tau_t^{SCee})W_t^iL_t^i+TR_t^{LC}=(1+\tau_{t+1}^C)P_t^CC_t^{LC}+\gamma_w/2(\pi_t^{w,i})^2P_t^CL_t^{LC}. \tag{5}$$

The weighted average of NLC and LC households' consumption constitutes for the per-capita level of aggregate consumption:

$$C\equiv(1-slc)C_t^{NLC}+slcC_t^{LC}. \tag{6}$$

Private demand for goods Z_t is a aggregate of tradable $(Z_{T,t}^i)$ and non-tradable $(Z_{NT,t}^i)$ goods. Assuming the same price elasticity for consumption and investment demand, we can combine domestically produced tradables $(C_{TH,t}^i, I_{TH,t}^i)$, non-tradables $(C_{NT,t}^i, I_{NT,t}^i)$ and imported goods $(C_{TF,t}^i, I_{TF,t}^i)$ to $Z_t\in(C_t^{NLC}, C_t^{LC}, I_t)$.

$$Z_t=[(\phi)^{\frac{1}{\psi}}(Z_{T,t})^{\frac{\psi-1}{\psi}}+(1-\phi)^{\frac{1}{\psi}}(Z_{NT,t})^{\frac{\psi-1}{\psi}}]^{\frac{\psi}{\psi-1}} \tag{7}$$

with ϕ and ψ as the share of tradable goods and the elasticity of substitution between tradable and non-tradable goods. $Z_{T,t}$ is a composite index of domestically produced $Z_{TH,t}$ and imported goods $Z_{TF,t}$:

$$Z_{T,t}=[(h)^{\frac{1}{\eta}}(Z_{TH,t})^{\frac{\eta-1}{\eta}}+(1-h)^{\frac{1}{\eta}}(Z_{TF,t})^{\frac{\eta-1}{\eta}}]^{\frac{\eta-1}{\eta}} \tag{8}$$

where h represents the steady-state home bias and η indicates the elasticty of substitution between domestically produced goods and imports.

The domestic producer price index (P_t^C) is given by:

$$P_t^C=[(\phi)(P_{T,t})^{1-\psi}+(1-\phi)(P_{NT,t})^{1-\psi}]^{\frac{1}{1-\psi}} \tag{9}$$

where the domestic country price index for tradable goods is:

$$P_{T,t}=[(h)(P_{TH,t})^{1-\eta}+(1-h)(P_{TF,t})^{1-\eta}]^{\frac{1}{1-\eta}}. \tag{10}$$

Households supply labour services to both tradable and non-tradable goods sectors. The labour services are distributed equally across NLC and LC households, and specialised labour unions represent the different types of labour services i in the wage setting. The wage setting is subject to quadratic adjustment costs, which provide an incentive to smooth the wage adjustment and lead to nominal wage stickiness. Since we assume identical wages W_t^i for both sectors, the optimisation problem of the labour union representing the labour service i is:

$$E_0 \sum_{t=0}^{\infty} \beta_t \left(-\frac{\kappa}{1+\varphi}(L_t^i)^{1+\varphi} + \lambda_t^i (1-\tau_t^w - \tau_t^{SCee}) \frac{W_t^i}{P_t^C} L_t^i - \lambda_t^i \frac{\gamma_w}{2} (\pi_t^{w,i})^2 \frac{P_{TH,t}}{P_t^C} L_t\right) \tag{11}$$

with a symmetric optimisation problem across unions i implying identical wages and labour demand across households.

Firms

The economy consists of a continuum of monopolistically competitive firms in the tradable and non-tradable sector. Firms are owned by NLC households which receive the profits. Each firm j produces a differentiated good $Y_{s,t}^j$ with capital $K_{s,t-1}^j$, labour $L_{s,t}^j$ and a Cobb-Douglas production technology in each sector s:

$$Y_{s,t}^j = A_{s,t} (K_{s,t-1}^j)^{\alpha} (L_{s,t}^j)^{1-\alpha}. \tag{12}$$

The sector-specific total factor productivity $A_{s,t}$ is identical across firms and follows an AR(1) process. The cost-minimal combination of capital and labour implies for the nominal marginal costs $MC_{s,t}^j$ of the optimising firm:

$$MC_{s,t}^j = \frac{(i_t^k)^{\alpha} [(1+\tau_t^{SCer}) W_t]^{1-\alpha}}{A_{s,t} \alpha^{\alpha} (1-\alpha)^{1-\alpha}}. \tag{13}$$

The firms in each sector s face quadratic price adjustment costs γ_p and prices $P_{s,t}^j$ to maximise the discounted expected profit. For each sector, firms profit maximisation has the following form:

$$E_0 \sum_{t=0}^{\infty} \beta_t \frac{\lambda_t^{NLC}}{\lambda_0^{NLC}} (\frac{P_{s,t}^j}{P_{s,t}} Y_{s,t}^j - \frac{1 + \tau_t^{SCer} W_{s,t}^j}{P_{s,t}} L_{s,t}^j - \frac{\gamma_p}{2} (\pi_{s,t}^{p,j})^2 Y_{s,t}). \tag{14}$$

The nominal GDP is the sum of domestically produced tradable and non-tradable output:

$$P_t^Y Y_t = P_{TH,t} Y_{T,t} + P_{NT,t} Y_{NT,t}. \tag{15}$$

Government Sector

The government collects labour, capital, consumption and lump-sum taxes, levied only on NLC households, as well as social security contribution (SSC) for employers and employees and issues one-period bonds to finance government purchases, transfers and the servicing of outstanding debt:

$$\begin{aligned} &(\tau_t^w + \tau_t^{SCee} + \tau_t^{SCer}) W_t L_t + \tau_t^k (i_t^k - \gamma) K_{t-1} + \tau_t^c P_t^C C_t + (1 - slc) TAX_t + B_t \\ &= P_t^G G_t + TR_t + (1 + i_{t-1}) B_{t-1}. \end{aligned} \tag{16}$$

Expenditure on total government purchases is the sum of expenditure on tradable and non-tradable goods analogously to private demand:

$$P_t^G G_t = P_t^T G_{T,t} + P_t^{NT} G_{Nt,t}. \tag{17}$$

Steady-state government consumption is given by:

$$\frac{G_t}{Y_t} = \rho_G \frac{G_{t-1}}{Y_{t-1}} \frac{Y_{t-1}}{Y_t} + (1 - \rho_G)(\frac{\bar{G}}{Y}) \tag{18}$$

and government adjusts lump-sum taxes to stabilize government debt and the budget deficit at their target levels.

The central bank sets interest rates according to the simple rule:

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(1-\beta)/\beta + (1-\rho_i)\xi_\pi(\frac{P_t^C}{P_{t-1}^C}) - \xi_E E_t. \tag{19}$$

External account

The total demand for domestic output is the sum of final domestic demand, net exports and the wage/price adjustment costs ADC_t:

$$P_t^Y Y_t = P_t^C(C_t + I_t) + P_t^G G_t + P_t^{TH} X_t - P_{TF,t} M_t + ADC_t. \tag{20}$$

Exports X_t correspond to the import demand of the rest of Monetary Union:

$$X_t = (1-h)(P_{TH,t}/P_{TH,t}^*)^{-\eta} Y_t^* \tag{21}$$

where h is the degree of home bias. We exclude price discrimination between countries, i.e. the law of one price holds. The aggregate resource constraint of the domestic economy, which is also the law of motion for NFA positions, is given by:

$$B_{H,t}^* = (1+i_{t-1})B_{H,t-1}^* + P_t^Y Y_t - P_t^C(C_t + I_t) - P_t^G G_t - P_t^Y ADC_t. \tag{22}$$

The current account equals the change in NFA positions:

$$CA_t = B_{H,t}^* - B_{H,t-1}^*. \tag{23}$$

We treat (the rest of) Monetary Union (foreign economy) as a single, large country, which engages in trade with the small country. However, the trade volume with the small country is low such that the foreign economy is seen as a closed one.

3 Estimation

In this paper, we apply a two-step estimation procedure involving calibration and Bayesian techniques in order to model a small open economy with financial frictions for two cases (BELL and GIP) following Schorfheide (2000) and Schorfheide and Lubik (2003). We use quarterly data for GIP and BELL from 2003Q1 to 2015Q4, including real GDP and consumption per capita, CPI inflation, real exchange rate, government expenditure and current account. In the case of GIP, public capital flows in form of TARGET2 data are added to NFA positions in order to replace private capital flows when the credit constraint binds. This period was chosen because it covers the sudden dry up of private capital inflows into BELL as well as GIP (starting in 2007) and the different adjustment processes in both regions after the financial crisis.

Calibration and prior specification

We follow the DSGE literature and calibrate the values for the discount factor, the real ratios of the model, such as consumption, investment and government spending shares on the basis of national accounts data, the share of LC households, the capital share, and tax rates. The calibrated parameters are summarized in Table 1. Here, a distinction must be made between calibrated parameters in BELL and GIP.

The steady-state ratios are calibrated to replicate the average share of private consumption (60%), investment (20%) and government purchases (20%) in Euro area GDP during $2003Q1-2015Q4$. The corresponding values for the group of Bulgaria, Estonia, Latvia and Lithuania vary only by 1% to 2%. The average government debt-to-GPD ratio is set to 74%. The budget closure implies that a 1 percentage point increase in government debt-to-GDP ratio increases taxes or decreases transfers by 0.001 percentage points. As debt levels are significantly lower in BELL, the model is estimated with data of government debt as robustness.

The tax rate on consumption of 19.7% is given by the average VAT rate within the Euro area for the period 2003-2015 (European Commission, 2013). The average tax

Table 1: Calibrated parameters and steady state ratios

Parameter	symbol	value
β	discount factor	0.995
C/Y	Consumption relative to GDP	0.6
G/Y	Government spending relative to GDP	0.2
I/Y	Investment relative to GDP	0.2
T/Y	Tradable goods share relative to GDP	0.6
TR/Y	General transfers relative to GDP	0.12
slc	Share of LC households	0.4
κ	Weight of labour dis-utility	1.0
$1/\varphi$	Elasticity of labour supply	0.25
θ	Elasticity of substitution for labour services i	6
α	Cobb-Douglas parameter (capital share)	0.4
γ_w	Wage adjustment costs	80
γ_p	Price adjustment costs	48
γ_c	Capital adjustment costs	30
$btar$	Debt-to-GDP ratio	0.74
ξ_b	Fiscal reaction to debt	0.001
ρ_G	Persistence of fiscal instrument	0.5
ρ_i	Persistence of monetary instrument	0.5
ξ_i	Monetary coefficient on inflation	1.5
τ^c	Consumption tax rate	0.197
τ^w	Labour income tax rate (incl. social security contribution)	0.29
τ^{SCer}	Social security contribution of employers	0.25
τ^k	Capital tax rate	0.30

rate on capital income is 30% (OECD Tax Database). Given the total gross earnings, households pay labor income tax and SSC as a percentage share of their gross wage earnings. The average labor income tax burden for the given period is 16% of total earnings plus 13% SSC for the households. According to Druant et al. (2012), we choose the wage and price adjustment cost parameters to match the average duration of wage and price adjustments of five and four quarters, respectively. The estimates for the share of liquidity-constrained (LC) households in the Euro area clusters around 40% in the literature and is set to slc = 0.4 (e.g. Ratto et al., 2009). The wage adjustment costs deviate in BELL and, therefore, would need a downward adjustment to fit the data. As labor market characteristics ought to be excluded, respective parameters are not estimated in this paper. However, lower parameters for the wage adjustment costs are tested with the result that a less rigid economy shortens the recovery process.

We follow Adolfson et al. (2007) in choosing prior distribution. For parameters bounded between 0 and 1, such as the persistence parameters, we use a beta distribution. Inverse gamma distributions are used for the standard deviation of shocks, where the mass of the distribution is concentrated at small values, but large values are still possible. For the rest, we employ normal and gamma distributions. The prior and posterior estimates for the benchmark model (BELL and GIP case) are displayed in Tables 2-3.

Table 2: Estimation results: GIP

		Prior			Metropolis-Hastings		
Parameter	description	Type	Mean	sd.	Mean	90% HPD interval	
ω	Country risk premium	Norm	0.0025	0.001	0.0064	0.0108	0.0012
σ	Inverse of intertemporal elasticity of substitution	Norm	1.5	0.2	1.2608	0.9232	1.5622
η	Trade elasticity between home and foreign	Norm	1.5	0.2	1.8945	1.6269	2.1836
ψ	Elasticity of substitution T/NT	Gamma	0.5	0.2	0.3758	0.1487	0.6040
ϵ	Elasticity of goods varieties j	Gamma	6.0	2.0	5.5432	2.9202	8.2355
h	Degree of home bias	Beta	0.5	0.1	0.3818	0.2600	0.4980
$1-\chi$	Credit constraint	Gamma	0.1	0.05	0.1313	0.0444	0.2227
ϕ	Share of tradable goods in consumption	Beta	0.6	0.2	0.4067	0.2998	0.5179
ρ_a	Persistence of TFP shock	Beta	0.6	0.1	0.8639	0.8083	0.9253
ρ_c	Persistence of consumption shock	Beta	0.6	0.1	0.7248	0.6059	0.8484
ρ_{rp}	Persistence of risk premium	Beta	0.6	0.1	0.9370	0.9157	0.9593
ρ_{χ}	Persistence credit constraint	Beta	0.6	0.1	0.6406	0.4802	0.7946
ρ_g	Persistence of government spending	Beta	0.6	0.1	0.6416	0.5101	0.7717
σ_a	Standard deviation TFP	InvG	0.01	0.02	0.0071	0.0045	0.0098
σ_{rp}	Standard deviation risk premium	InvG	0.01	0.02	0.0050	0.0030	0.0072
σ_{χ}	Standard deviation credit constraint	InvG	0.01	0.02	0.0032	0.0021	0.0042
σ_g	Standard deviation gov spending	InvG	0.01	0.02	0.0099	0.0071	0.0126
σ_{rpfor}	Standard deviation risk premium foreign	InvG	0.01	0.02	0.0237	0.0185	0.0284
σ_{afor}	Standard deviation TFP foreign	InvG	0.01	0.02	0.0373	0.0251	0.0485
σ_c	Standard deviation consumption	InvG	0.01	0.02	0.0193	0.0106	0.0287
σ_{yobs}	Standard deviation measurement shock Y	InvG	0.01	0.02	0.0123	0.0079	0.0168
σ_{cobs}	Standard deviation measurement shock C	InvG	0.01	0.02	0.0044	0.0026	0.0060
$\sigma_{\pi obs}$	Standard deviation measurement shock π	InvG	0.01	0.02	0.0036	0.0024	0.0048
σ_{rerobs}	Standard deviation measurement shock rer	InvG	0.01	0.02	0.0042	0.0032	0.0051
σ_{intobs}	Standard deviation measurement i	InvG	0.01	0.02	0.0035	0.0022	0.0046
σ_{gobs}	Standard deviation measurement G	InvG	0.01	0.02	0.0024	0.0018	0.0030
Marginal likelihood (Laplace approximation)		929.39					
Marginal likelihood (Harmonic mean)		929.83					
Average acceptance rate for each chain		0.3659	0.3655				

In a first step, we specify priors for the parameters and shocks. The prior information is shown in Columns 3-5 of Tables 2-3, summarizing the assumptions for the means, standard deviations, and the underlying distributions of the priors. The prior means are mainly based on calibrated parameter values used by Hohberger et al. (2014). In our estimations the endogenous part of risk premium ω, the inverse of the intertemporal elasticity of substitution σ, and the elasticity of substitution between home and foreign goods η are assumed to be normally distributed. As we are using quarterly data, the prior mean of the elasticity of risk premium ω of 0.0025 with a relatively loose standard deviation of 0.001 indicates a deterioration of 1 per-

Table 3: Estimation results: BELL

		Prior			Metropolis-Hastings		
Parameter	description	Type	Mean	sd.	Mean	90% HPD interval	
ω	Country risk premium	Norm	0.0025	0.001	0.0044	0.0084	0.0001
σ	Inverse of intertemporal elasticity of substitution	Norm	1.5	0.2	1.3600	1.0624	1.6420
η	Trade elasticity between home and foreign	Norm	1.5	0.2	1.8789	1.5999	2.1692
ψ	Elasticity of substitution T/NT goods	Gamma	0.5	0.175	0.6237	0.2967	0.9593
ϵ	Elasticity between goods varieties j	Gamma	6.0	1.25	5.9415	3.8446	7.7877
h	Degree of home bias	Beta	0.5	0.1	0.4244	0.2981	0.5559
$1-\chi$	Credit constraint	Gamma	0.1	0.05	0.0591	0.0253	0.0917
ϕ	Share of tradable goods in consumption	Beta	0.6	0.1	0.7746	0.6587	0.9018
ρ_a	Persistence of TFP shock	Beta	0.6	0.1	0.8537	0.7948	0.9106
ρ_c	Persistence of consumption shock	Beta	0.6	0.1	0.6013	0.4420	0.7645
ρ_{rp}	Persistence of risk premium shock	Beta	0.6	0.1	0.9538	0.9354	0.9724
ρ_χ	Persistence of credit constraint shock	Beta	0.6	0.1	0.7131	0.5634	0.8712
ρ_g	Persistence of government spending shock	Beta	0.6	0.1	0.6481	0.5035	0.8008
σ_a	Standard deviation TFP	InvG	0.01	0.02	0.0174	0.0136	0.0211
σ_{rp}	Standard deviation risk premium	InvG	0.01	0.02	0.0066	0.0028	0.0104
σ_χ	Standard deviation credit constraint	InvG	0.01	0.02	0.0036	0.0022	0.0051
σ_g	Standard deviation government spending	InvG	0.01	0.02	0.0202	0.0104	0.0290
σ_{rpfor}	Standard deviation risk premium foreign	InvG	0.01	0.02	0.0141	0.0108	0.0175
σ_{afor}	Standard deviation TFP shock foreign	InvG	0.01	0.02	0.0091	0.0035	0.0146
σ_c	Standard deviation consumption	InvG	0.01	0.02	0.0090	0.0028	0.0160
σ_{yobs}	Standard deviation measurement Y	InvG	0.01	0.02	0.0037	0.0024	0.0048
σ_{cobs}	Standard deviation measurement C	InvG	0.01	0.02	0.0056	0.0037	0.0075
$\sigma_{\pi obs}$	Standard deviation measurement π	InvG	0.01	0.02	0.0230	0.0189	0.0267
σ_{rerobs}	Standard deviation measurement rer	InvG	0.01	0.02	0.0327	0.0274	0.0384
σ_{caobs}	Standard deviation measurement CA	InvG	0.01	0.02	0.0094	0.0076	0.0111
σ_{iobs}	Standard deviation measurement i	InvG	0.01	0.02	0.0028	0.0020	0.0036
σ_{gobs}	Standard deviation measurement G	InvG	0.01	0.02	0.0110	0.0089	0.0130
Marginal likelihood (Laplace approximation)		996.75					
Marginal likelihood (Harmonic mean)		997.37					
Average acceptance rate for each chain		0.3410	0.3386				

cent in the NFA-to-GDP position with a corresponding increase of the annualized borrowing rate by 1 basis point. The prior means of σ and η are overall in line with other studies (e.g. Smets and Wouters, 2007; Rabanal and Tuesta, 2013). The elasticity of substitution between tradable and non-tradable goods ψ, the elasticity of substitution between goods varieties j ϵ and the parameter of credit constraint $(1-\chi)$ are assumed to be positive and gamma distributed. Although the prior means are the same across all estimations (BELL and GIP case), the standard deviation is adjusted. The estimation for BELL has tighter standard deviations regarding the elasticity of goods varieties and the elasticity of substitution between tradable and non-tradable goods. The persistence of shocks as well as the share of tradable goods in consumption ϕ are assumed to lie within the interval $[0, 1]$ with a beta distribution used for the prior shape. The prior mean of each shock persistence parameter is set to 0.6 with a standard deviation of 0.1. The value of the prior mean lies in the range of 0.5 and 0.8 suggested by Marcellino and Rychalovska (2012) and Justiniano and Preston (2010). For the share of tradable goods in consumption ϕ, the standard deviation is reduced to 0.1 in the case of BELL. In order to estimate the standard deviation of shocks and the measurement errors, inverse gamma distributions with prior means of 0.01 and loose standard deviations of 0.02 are specified. Similar values can be found in Almeida (2009), who set the prior means equal to the standard deviations to form uninformative priors.

After the specification of priors, we run 50,000 draws with two distinct chains, using Metropolis-Hastings algorithm. To account for any dependence of the chains from its starting values, the first 50 percent are dropped as burn in (Röhe, 2012). Estimation results from Metropolis-Hastings are shown in the last three columns of Tables 2-3, involving the posterior mean and the Highest Posterior Density Interval (HPDI)[2]. The last three rows of Tables 2-3 contain the values of the marginal likelihood (Laplace approximation and Harmonic mean estimator) as well as the average acceptance ratio of the Metropolis-Hastings algorithm of each chain.

Comparing the posterior estimates of GIP and BELL, the endogenous part of the risk premium ω increases with the provision of public capital flows. This is because countries outside the EMU face a dry out of private credit from abroad that is not replaced by public capital. Hence, lower capacity of foreign indebtedness improves the risk premium on interest rate. The credit constraint parameter $(1-\chi)$ is higher for GIP than for BELL highlighting the importance of additional TARGET2 flows in equation (2) in the GIP case. More precisely, the contribution of TARGET2 increases in the credit constraint parameter.

Another difference in this context can be seen in the shock persistence. Especially in case of consumption or TFP shocks, Tables 2-3 show longer shock persistence in GIP than in BELL. Countries outside EMU are hit harder by a sudden stop and react faster than their counterparts inside EMU, where the shock to the economy

[2]In contrast to confidence intervals, the HPDI has two important properties: First, the density for each point lying within the interval is greater than for those points lying outside. Second, the interval is of the shortest length for a default probability content (e.g. $(1-\alpha)$ (Chen and Shao, 1999)).

is smoother and more persistent. This leads to a faster recovery of the group of countries outside EMU (Gros and Alcidi, 2014). In case of credit constraint shocks, shocks are more persistent in BELL indicating a high exposure of the respective countries to sudden stops.

In order to evaluate our estimation and to check for robustness and sensitivity, we estimate the models for GIP and BELL with different prior specifications. Following Almeida (2009), we change the prior mean and the standard deviation by 10 percent. Additionally, we estimate with very loose prior standard deviations (50 percent plus on initial standard deviation) and initial prior means. While in the latter case, some posterior means show higher sensitivity than in the former case, the estimation results are robust. Furthermore, we modify the corresponding period to 2005Q1 to 2015Q4 without a change in the estimation results. Moreover, all parameters are identified[3].

4 Simulation

The sudden stop is simulated by implementing a binding collateral constrained on foreign indebtedness associated with negative NFA positions. The mechanisms at work are the following in case of a TFP shock:

A current account deficit (and with that negative NFA positions) induced by a negative TFP shock causes the collateral constrained to bind and leads to a sudden outflow of private capital from the small open economy. According to the optimal consumption path for foreign NLC consumers, the investment decision is in favor of domestic bonds instead of foreign bonds (of the small open economy). Here, we distinguish between two cases, namely a private capital outflow of a country outside the EMU (BELL case) and a member country of the EMU (GIP case) where the flow of private capital is substituted by public capital flows (e.g. TARGET2).

We analyze the differences in the adjustment process after a sudden stop by simulating a negative TFP shock under different model and policy settings: First, we

[3]Under application of the Dynare identification toolbox, developed by the Joint Research Centre.

show impulse-response functions (IRF) for the domestic economy in the absence of a collateral constraint and ECB assistance (benchmark case). Second, we examine the effects of a binding credit constraint on negative NFA positions (BELL case) in order to imitate the private capital outflow from Baltic States and Bulgaria after the financial crisis. Third, we include IRFs for the case that the domestic economy is a member of EMU and receives ECB assistance in form of TARGET2 by closing the gap between the benchmark case and the BELL case (GIP case). The gap in NFA positions is defined conventionally as percentage point (relative to GDP) deviation of the actual level from the level that would exist due to the sudden stop. Impulse responses are specified in percent relative to GDP, except those for consumption and inflation, which are given in percent and percentage points, respectively.
Figure 1 shows impulse responses (IRFs) for a negative economy-wide TFP shock, simulated as a temporary 2.5 percentage point decline of the total factor productivity relative to the rest of monetary union. In the benchmark case price stickiness delays the increase in domestic prices and lowers real interest rates, so that consumption and investment declines moderately. The increase in employment is associated with the lower productivity level when prices and wages are sticky. The delayed increase in the real exchange rate leads to an increase in negative NFA positions and with that a negative current account in the medium term. The binding collateral constraint (BELL case), indicated by an increase of the interest rate risk premium ψ, triggers a sudden reverse of private capital flows, if NFA exceed a certain share of GDP defined by $(1-\chi)$ in equation (2). The finance of domestic demand through private capital inflows dries up and causes a sharp decrease in consumption and investment relative to the benchmark case. The lack of demand for consumption and investment as well as domestic government bonds results in an increase of government debt that levels off quickly due to low interest rate risk premiums on foreign debt. This is the difference between the BELL case and the GIP case in our model: Due to the ECB assistance via TARGET2, the domestic country experiences an inflow of public capital that substitutes the outflow of private capital in form of NFA. Therefore, the negative effects that would prevail under a sudden stop are mitigated by artifi-

cial maintenance. Additionally, the increase in government debt is smaller but also delayed, as an increase in the risk premium on foreign debt ensures continuously higher interest rates on sovereign bonds. The same holds for consumption, especially consumption of LC households: households experience a drop in consumption that is sharper in the BELL case than in the GIP case but quicker in the adjustment process.

Figure 3 shows the IRFs for a negative risk premium shock causing a demand boom.

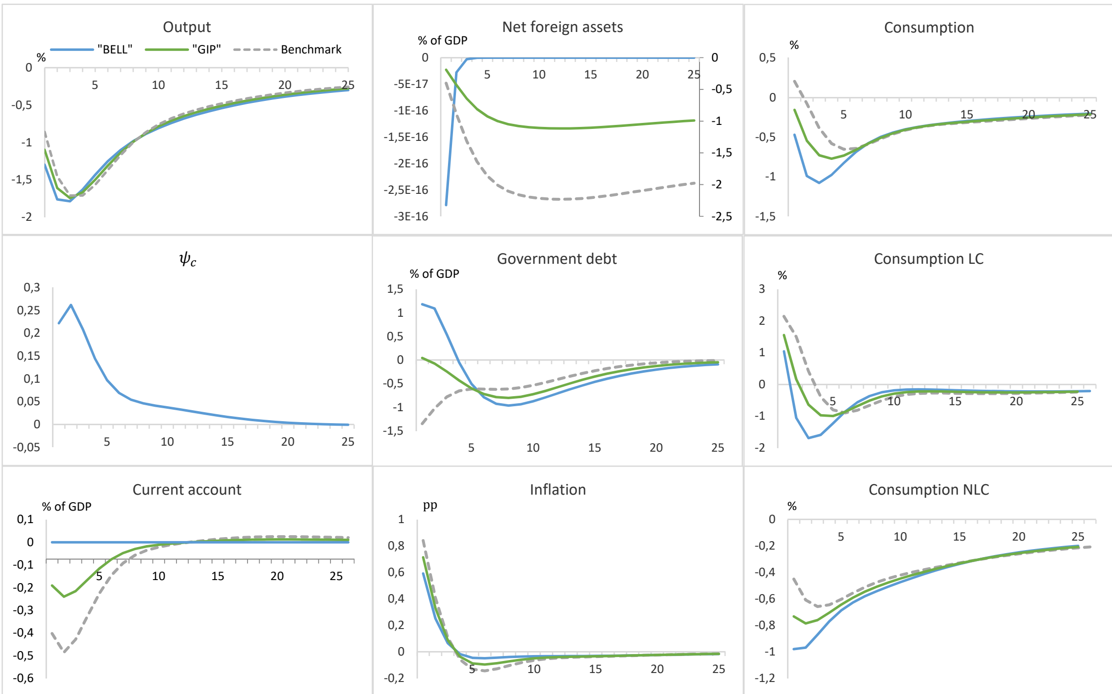

Figure 2: Sudden stop in response to a negative TFP shock

In the benchmark case, the negative shock reduces domestic borrowing rates in the economy and causes a demand boom. Nominal rigidities delay the upward pressure on prices and wages, leading to a decrease in the real interest rates. Therefore, demand further increases, which also affects the trade balance and NFA positions: they deteriorate. In the BELL case, the economy is prevented from foreign indebtedness, and thus, the effects of the negative risk premium shock are fully split between a decrease of investment, as the economy is not an investment option for foreign investors, and a slight increase in consumption. Additionally, the government profits from lower interest rates with a decrease in government debt. Consumption levels remain on a relatively higher level in GIP than in BELL. However, the possibility of foreign indebtedness leads to an increase in the interest rate and therefore to a rapid surge in government debt.

After discussing the main relationships and differences of the model with and with-

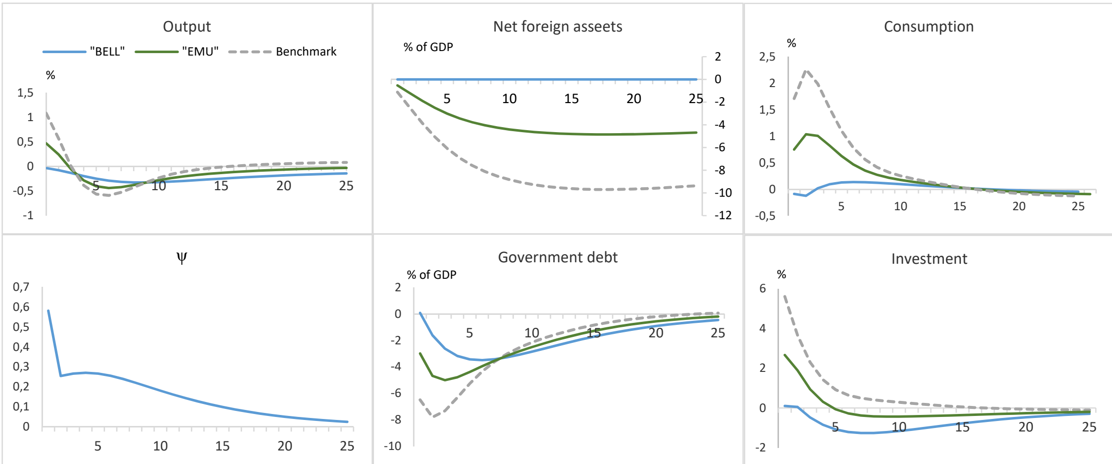

Figure 3: Sudden stop in response to a negative risk premium shock

out financial frictions for two representative shocks, we evaluate historical shock decompositions and Bayesian impulse responses of the estimated model in order to further elaborate the characteristics of BELL and GIP.

5 Results

Historical shock decomposition

We estimate the individual contributions of each shock to the movements of the endogenous variables output, consumption, NFA positions (relative to GDP) and current account (relative to GDP).

Figure 4.a-c plots the historical shock decomposition of GIP (a1-c1) and BELL (a2-c2). The black line depicts the smoothed value of the historical quarterly data series of the corresponding endogenous variable from its steady state, whereas the vertical bars show the contribution of different groups of smoothed shocks to the data of the respective variable.

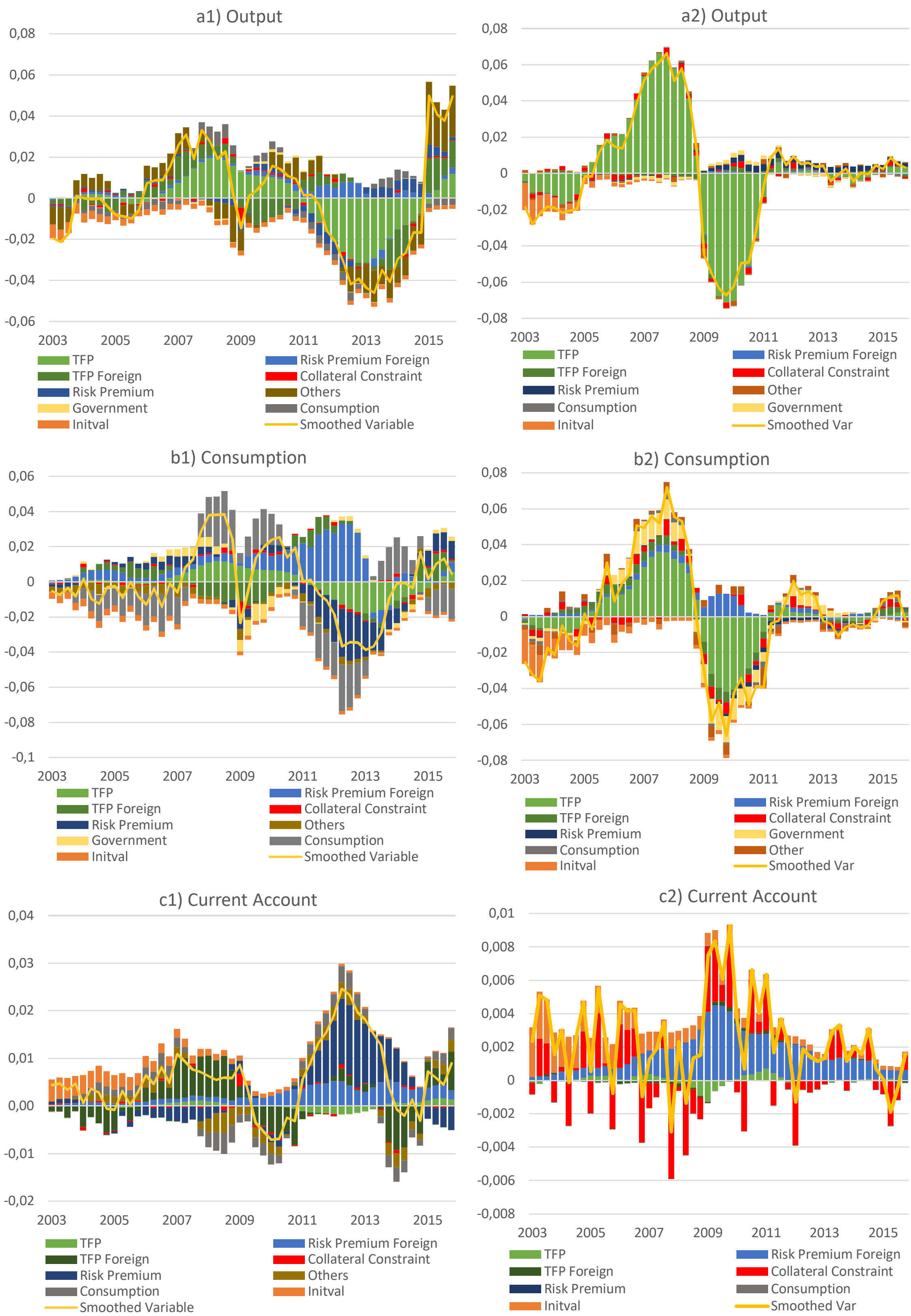

Figure 4: Historical shock decomposition for GIP and BELL

The historical decomposition shows that TFP shocks have a noticeable effect on domestic output for GIP as well as BELL throughout the whole sample, whereas the influence of risk premium shocks on output is apparent since the beginning of the financial crisis, particularly in GIP. Due to TARGET2 and the associated increase in risk premium on sovereign debt, consumption and current account patterns are highly influenced by risk premium shocks in GIP from 2010 onwards (see also Gourinchas et al., 2016). The influence of a tightening and relaxing collateral constraint is higher and more persistent for BELL, in 2009 however, a tightening collateral constraint is responsible for the sharp but non-permanent decrease in output of GIP. This might be due to the fact that GIP had to deal with the negative effects of the financial crisis, while ECB assistance programs rarely existed at that point.

Additionally, the shock decomposition of consumption varies widely between the two groups of countries. While consumption is mainly characterized by consumption shocks in GIP, consumption in BELL is more influenced by TFP and pro-cyclical government shocks.

Comparing the shock composition of current account for GIP and BELL, the influence of the collateral constraint is continuously high in the BELL case, and apart from the short period around the outbreak of the financial crisis quasi non-existent in the GIP case. The contribution of foreign monetary shocks to the domestic current account is highly positive throughout the sample in the BELL case and only significant from 2011 to the end of the sample in the GIP case.

Bayesian Simulation

Figure 5 shows the Bayesian IRFs of a negative TFP shock. The IRFs (responses at the posterior mode of the parameters) together with the HPDI (blue shaded area) support the results from the calibrated simulation above. The initial drop in output and consumption is more severe, the adjustment process quicker in BELL compared to GIP. Government debt in BELL increases with the onset of the negative TFP shock, but falls sharply after five periods recording even negative percent values (relative to GDP). This supports the results from the historical decomposition, namely that government did not increase but rather decreased their expenditure during crisis times.

In case of a negative risk premium shock (Figure 6), BELL show a low response of

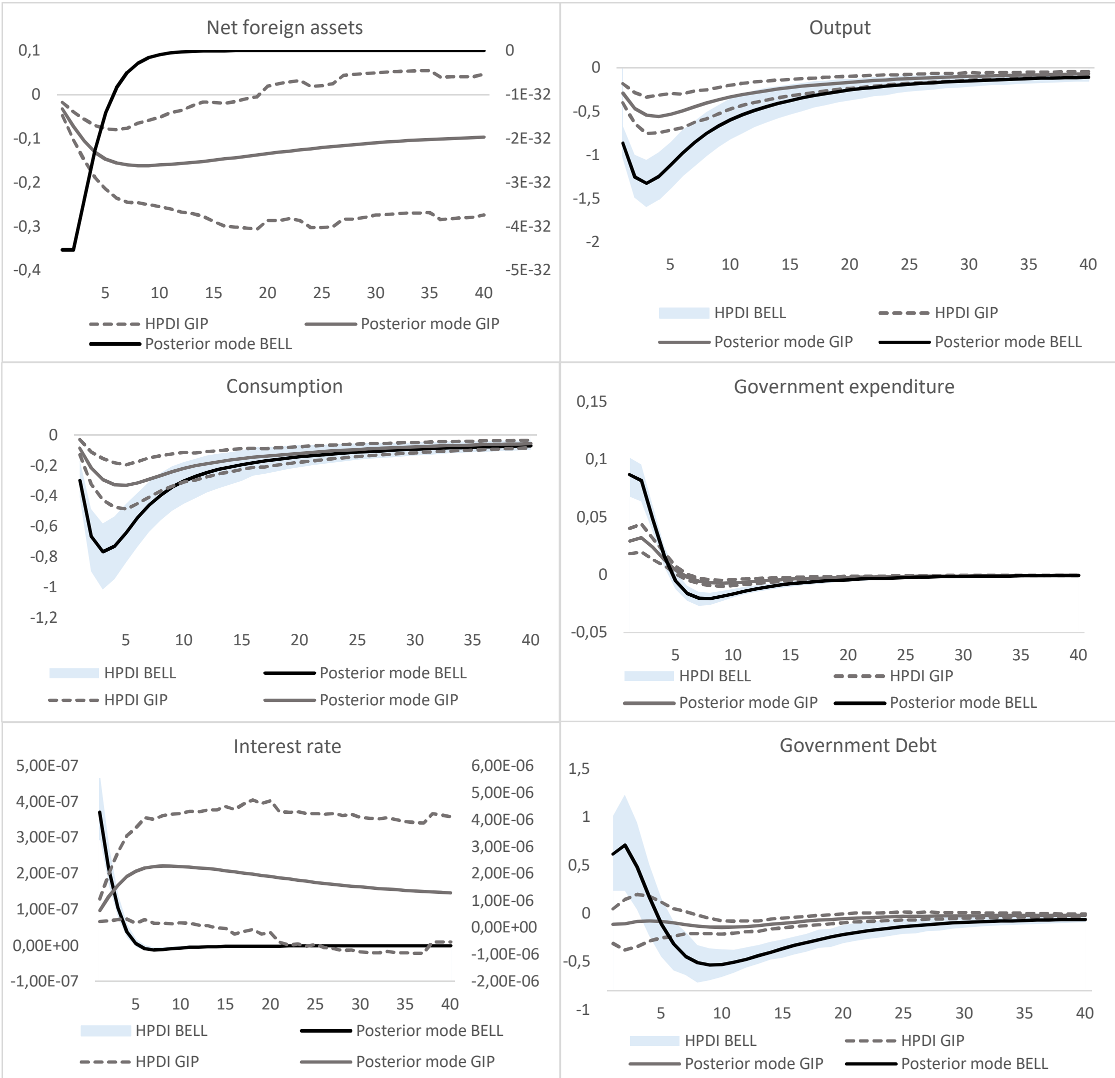

Figure 5: Bayesian IRF for a negative TFP shock

consumption and output, and government debt decreases due to lower interest rates as expected. GIP exhibit an increase in output and consumption that is supported by public capital flows in form of TARGET2. However, the rapid increase in net foreign debt (negative NFA positions) leads to a rebound of the interest rate and a surge in government debt after five periods.

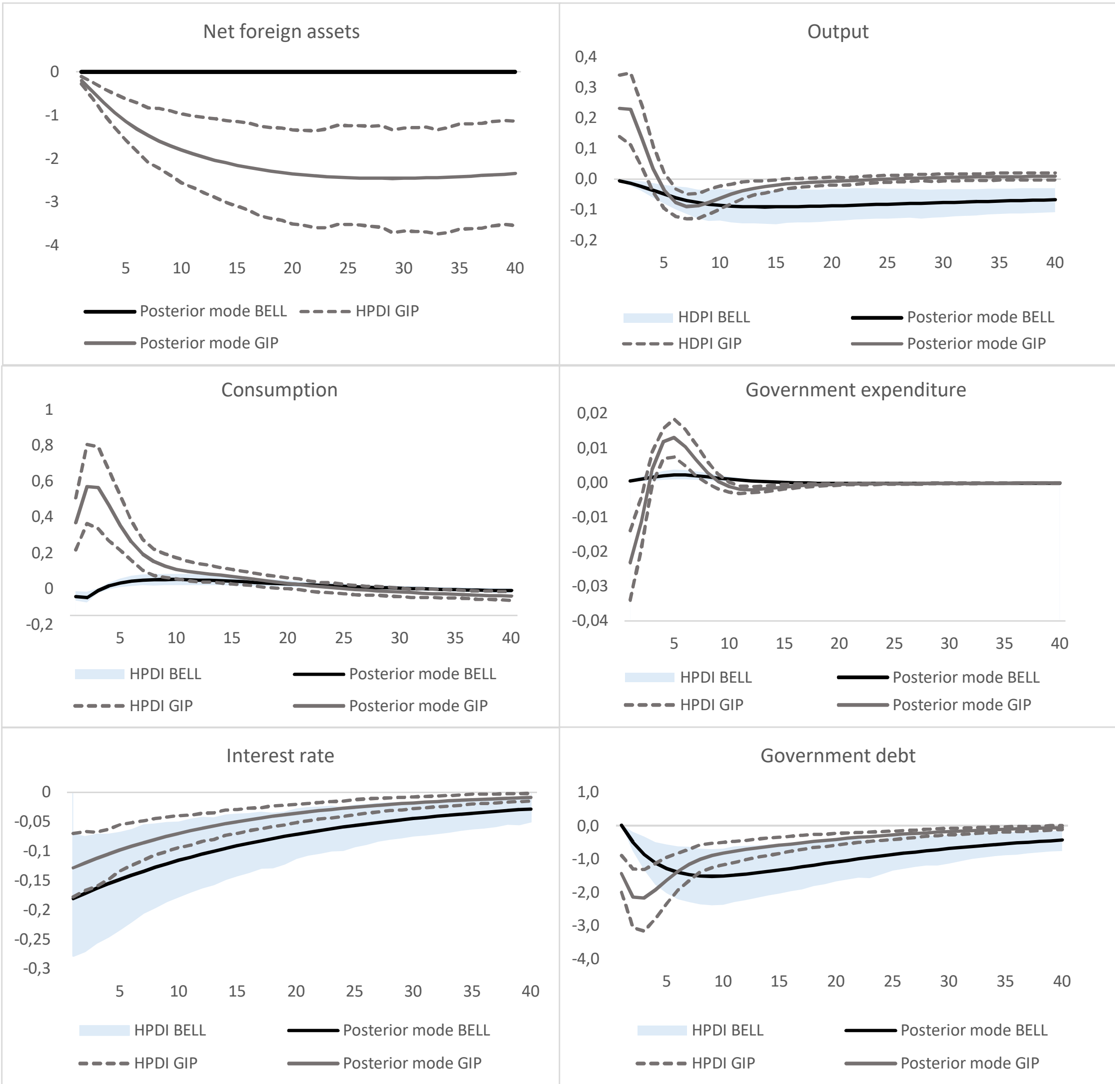

Figure 6: Bayesian IRF for a negative risk premium shock

6 Conclusion

This paper uses a two-sector DSGE model of a small open economy in Monetary Union or pegged to it with nominal and real rigidities to analyze the the differences in the adjustment processes in case of a sudden stop of private capital inflows. In the GIP case, the sudden stop even turned into a reversal of private capital flows. We contribute to the existing literature by (i) modeling sudden stops of private capital inflows into a small open economy that is pegged to the euro with and without public capital as private capital replacement (ii) estimating the model for two representative groups of countries, namely the GIP and the BELL. We compare the estimated parameter results of the group of countries inside EMU with those pegged to EMU.

The simulations of a negative TFP shock as well as a negative risk premium shock suggest that although public capital flows in form of TARGET2 lessen the initial negative effects of a sudden stop of private capital to output, consumption, investment and government debt, they delay the subsequent adjustment process of the respective macroeconomic variables. An estimation and the resulting Bayesian IRFs of two representative groups of countries confirm the results from the simulation. A higher confidence in intra-Eurosystem TARGET financing is shown by a tighter credit constraint parameter for GIP relative to BELL whose adjustment to a sudden stop only appears in NFA positions. Additionally, the results show that countries inside EMU bear a higher risk premium on foreign debt as they do not have a restriction on NFA positions due to TARGET2 balances. Furthermore, higher shock persistence for TFP and consumption indicate smoother but more persistent effects of a sudden stop in GIP relative to BELL. A historical shock decomposition and Bayesian IRFs support the results from the calibrated simulation.

Our results are robust to changes in the estimation period, the inclusion of government debt as observable data, the removal of TARGET2 as observable data (the latter showing the indirect influence of TARGET2 via current account), and changes in the prior specification.

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