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Sudden stops inside and outside the euro area - what a difference TARGET2 makes

Lena Kraus, Universität Bayreuth
Jürgen Beier, Universität Bayreuth
Bernhard Herz, Universität Bayreuth

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Abstract

During the Great Financial Crisis several European countries - both inside and outside the euro area - suffered sharp reversals of private capital inflows. We examine how macroeconomic adjustments to sudden stops differ between members of the euro area and countries pegging the euro, the closest alternative to joining the euro. We focus on a key difference between a conventional euro peg and full euro membership: the quasi-automatic public financing of external deficits via the euro area payments system TARGET2. Our simulation results indicate that access to TARGET2 helps to mitigate the adverse effects of a sudden stop on output, consumption and investment, at least in the short run. As a drawback economic rebalancing is prolonged and accompanied by a considerable build-up of public debt. In contrast, euro peggers without access to public external finance suffer a sharp economic downturn when subject to a sudden stop. On the upside, economic recovery is prompt and government debt remains stable. Estimation results for a group of euro area members and euro peggers are in line with our simulation results.

JEL-Codes: D53, E58, F32, F41, G15.
Keywords: Sudden stops, TARGET2, collateral constraint, capital flows.

1 Introduction

Since the mid-1990s many European countries experienced a long period of substantial GDP growth, accompanied by ever increasing current account deficits. With the advent of the Great Financial Crisis this expansion came to an abrupt end as sharp reversals in private capital flows forced massive macroeconomic adjustments with negative effects on output and employment. This pattern of mounting external deficits followed by sudden stops is too well-known, again this time was not different (e.g. Reinhart and Calvo, 2000; Calvo et al., 2006; Mendoza and Terrones, 2008; Merler and Pisani-Ferry, 2012; Reinhart and Rogoff, 2009). Yet, in the unfolding crisis a striking difference became apparent between euro area Member States and countries pegging the euro, the closest alternative to euro membership (see also Gros and Alcidi, 2014).

Strict euro peggers such as Bulgaria and the Baltic states experienced a severe but quick adjustment in output and current account. Two years into the crisis their current account was again balanced, and shortly after, their GDP had recovered to pre-crisis levels. In contrast, euro area members like Greece, Ireland and Portugal saw a more moderate yet extended adjustment process which was accompanied by a massive built up of public foreign debts in the form of so-called TARGET2 liabilities (see **Figure 1**).

From a currency regime perspective both groups of countries are members of nominal fixed exchange rate regimes, however, under distinctly different 'rules of the game'. The euro peg is an asymmetric fixed exchange rate regime in which the adjustment burden in case of external imbalances - positive as well as negative - lies with the pegging country. Shock induced changes in the exchange rate bring about changes in the pegging central

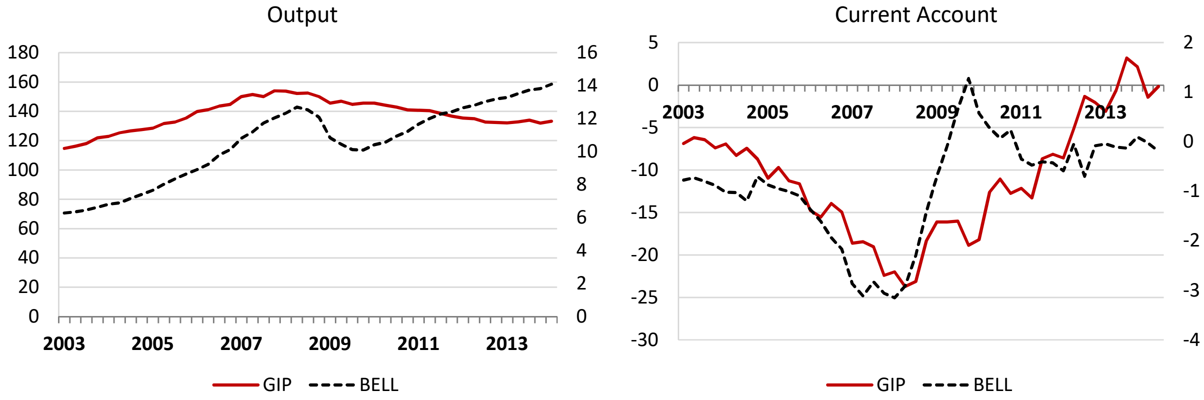

Figure 1: Output and Current account (mill. EUR)
Note: Aggregated for Greece, Ireland, and Portugal (GIP) as well as Bulgaria, Estonia, Latvia, and Lithuania (BELL).

bank's monetary policy, either directly or indirectly via foreign exchange interventions. In contrast, the euro area can be taken as a symmetric fixed exchange rate regime in which participating central banks intervene inversely and share the burden of adjustment equally. The overall monetary stance of the currency union does not change as monetary contractions in the deficit countries are balanced by monetary expansions in the surplus countries (Herz and Roeger, 1992). However, the euro area is a very specific type of symmetric fixed exchange rate system. Private capital net outflows are automatically financed by public capital inflows in the form of TARGET2 liabilities, i.e. surplus countries implicitly grant an unlimited swap line to deficit countries via the euro payment system (Sinn and Wollmershäuser, 2012; Westermann, 2014). As the reserve constraint does not bind, the euro area lacks an important balance of payment mechanism to reduce imbalances between member countries.

Our goal is to analyze how the automatic access to public external finance via the TARGET2 payment mechanism has affected the macroeconomic adjustment of euro area Member States during sudden stops in the Great Financial Crisis. With a decade into the crisis sufficient data should be available to address important questions on the effects of TARGET2. Is euro area membership advantageous as it allows a more flexible adjustment to sudden stops due to the quasi-automatic access to external public capital flow via the euro payment system? Does the easy access to external finance turn into a disadvantage in the long run as countries might be tempted to delay necessary adjustments, e.g. wage and price adjustments as well as government budget consolidation?

Our analytical framework is a small open economy DSGE model (Corsetti et al., 2017, 2013). We account for the policy restrictions implied by fixed exchange rate regimes and relate sudden stops to a credit constraint analogous to financial frictions in the form of collateral constraints tied to the housing sector (e.g. Roeger and in't Veld, 2009; Iacoviello, 2005; Iacoviello and Neri, 2010). Analyzing the macroeconomic consequences of sudden stops, Mendoza (2010) who includes an occasionally binding collateral constraint into an equilibrium business cycle model finds a negative impact on output and consumption amplified by a decline in domestic asset prices. In contrast to Bernanke et al. (1996), who model a sudden stop as an exogenous shock to external financing premium, he triggers sudden stops endogenously by productivity and interest rate shocks that cause a binding constraint on foreign debt. We modify this approach and directly relate credit constraints to net borrowings from the foreign economy, in order to focus on the effects of sudden stops on current account dynamics.

Following the Calvo et al. (2004) definition of a sudden stop as an abrupt and sizable reversal of capital flows Lane and Milesi-Ferretti (2011) confirm sudden stops for euro area member countries during the Great Financial Crisis. This view is supported by Merler and Pisani-Ferry (2012), who find evidence of private capital flows being replaced by public capital in form of TARGET2 imbalances. Based on Mendoza (2010), Fagan and McNelis (2014) augment a calibrated model with TARGET2 financing by relating TARGET2 balances to interest rate spreads. In addition, the authors provide an welfare analysis that suggests only small welfare gains due to the effects of precautionary savings. In a policy analysis Gros and Alcidi (2014) find important differences in the economic adjustment to sudden stops inside and outside the euro area which they relate to differences in the currency regimes. Particularly, they point to the easy access to external finance that euro area members implicitly have via the TARGET2 payments system.

To empirically analyze the adjustment process to sudden stops inside and outside the euro area, we estimate our small open economy model for Greece, Ireland, and Portugal (GIP) as a group of peripheral euro members for the period 2003-2013. For a better appraisal of the underlying adjustment processes, we take Bulgaria, Estonia, Latvia, and Lithuania (BELL), a group of generic euro peggers, as a quasi counterfactual.[1] Building on these estimates, we evaluate the historical shock decomposition of endogenous variables for the two country groups, and discuss the respective Bayesian impulse response functions.

Based on financial frictions, we allow for several shocks to endogenously determined sudden stops of private capital inflows that induce a credit constraint on foreign borrowings to bind. We contribute to the existing literature in two dimensions: (i) We explicitly account for the institutional differences between conventional euro peggers and euro area Member States with access to the TARGET2 system. (ii) We estimate the model for two groups of representative countries and analyze how differences in access to external finance affected the macroeconomic adjustment to sudden stops during the Great Finan-

[1] In the mean time, Estonia (2011), Latvia (2014) and Lithuania (2015) joined the euro area.

cial Crisis. Additionally, the estimation results are tested for robustness.

We find that - in the short run - TARGET2 helped euro area deficit countries to stabilize output, consumption, and investment relative to euro peggers that did not have access to such official loans. In the long run, however, euro area countries experienced a prolonged economic recovery and accumulated larger public debt than the euro peggers.

The remainder of the paper proceeds as follows. Section 2 describes the theoretical model. To illustrate the effects of a binding collateral constraint, Section 3 presents simulation results for a number of shocks with negative effects on net foreign asset (NFA). Section 4 outlines the estimation strategy, describes the data, and motivates the posterior results for the estimated parameters. Section 5 discusses the results of the estimation in form of a historical shock decomposition of selected endogenous variables. Section 6 concludes and address some policy implications of our analysis.

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 differentiated into liquidity constrained (LC) households 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 how the effects of a sudden stop differ between countries inside and outside the euro area. Reversals in capital flows are induced by a credit constraint on the NFA positions of NLC households analogous to Roeger and in't Veld (2009) that restricts private foreign indebtedness when the premium on households' borrowings from abroad increases. We compare the effects of the binding credit constraint in the case of euro outsiders (BELL) with the case of euro insiders (GIP) where public capital flows substitute private capital flows via the TARGET system. Following Schmitt-Grohe and Uribe (2003), we use 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 with a home bias in the demand for goods. Labor is immobile between countries. 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, the small open economy outside Monetary Union pegs her currency to the euro. For the sake of brevity, this section only displays the main equations of the model setting. The detailed description of the baseline model can be found in Hohberger et al. (2014). Fig. 1 summarizes the model structure.

Financial friction

NLC households face a credit constraint $(1-\chi)$ that relates domestic NFA positions to households investment decisions:

$$B^*_{H,t} + \mathit{TARGET2} - (1-\chi)P^Y_t I_t = 0. \tag{1}$$

Equation (1) restricts the domestic economy when refinancing on international capital markets via the Lagrange multiplier ψ_c as in equation (2). The basic mechanism is the following: With an increase in the risk premium of stressed countries the credit constraint $(1-\chi)$ tightens and the Langrange multiplier ψ_c acts like a premium on the interest rate that forces down foreign indebtedness and thus domestic investment and consumption (see Roeger and in't Veld, 2009, for an application in the real estate sector). In the special case of euro insiders, a reversal of private capital inflows is (partly) compensated by an increase in *TARGET2* when the credit constraint binds. These *TARGET2* liabilities allow for larger negative NFA positions and are captured in the estimation by the *TARGET2* data of the respective countries. From the benchmark case of no credit constraint we determine the NFA position without financial friction and compare it to the NFA position under the credit constraint. In the limiting case of a smoothly working *TARGET2* system the missing private capital inflows would be completely substituted by public external finance. Our estimation results indicate that in practice the *TARGET2* system indeed come very closely to this limiting case. *TARGET2* liabilities are linked to the country-specific risk premium ω on foreign debt so that additional public capital flows drive country-specific risk premium on interest rates as in equation (3).

Households

The optimal consumption path for NLC households is given by:

$$\beta E_t\left(\frac{1+\tau_t^C}{1+\tau_{t+1}^C}\frac{P_t^C}{P_{t+1}^C}\left(\frac{C_t^{NLC}}{C_{t+1}^{NLC}}\right)^{\sigma}\right)=\frac{1-\psi_c}{1+i_t} \tag{2}$$

where ψ_c is the Lagrange multiplier on the credit constraint for NFA positions and correlates positively with a tightening constraint.

The interest parity condition

$$i_t = i_t^* - \omega \frac{B_{H,t-1}^*}{4P_{t-1}^Y Y_{t-1}} + \epsilon_t^r \tag{3}$$

includes the country risk premium with $\omega > 0$ and ϵ_t^r as an exogenous AR(1) risk premium shock.

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 labor supply. For

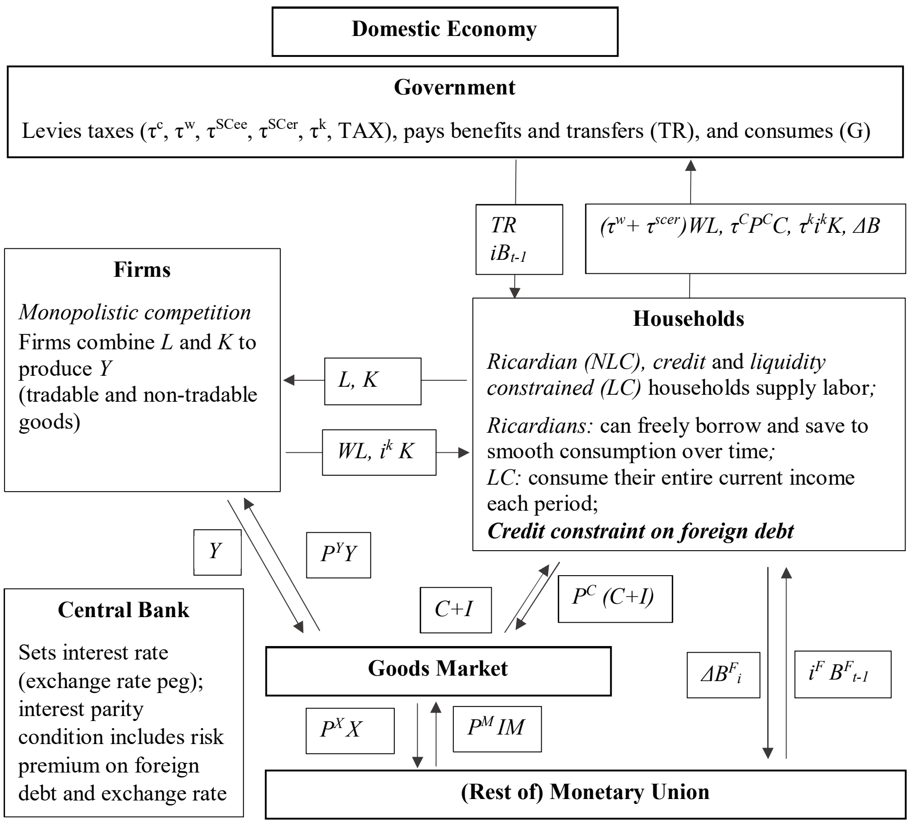

Figure 2: Model structure

NLC households, who are a fraction $(1 - slc)$ of the population, the intertemporal budget constraint is given by:

$$
\begin{aligned}
&(1-\tau_t^w-\tau_t^{SCee})W_t^iL_t^i+(1+i_{t-1})B_{t-1}+(1+i_{t-1}^*-\omega\frac{B_{H,t-1}^*}{4P_{t-1}^YY_{t-1}}+\epsilon_t^r)B_{t-1}^*+\\
&TR_t+(1-\tau_t^k)i_t^kK_{t-1}^i+\tau_t^k\gamma P_t^CK_{t-1}^i+PR_t \\
&=(1+\tau_t^C)P_t^CC_t^[NLC]+P_t^CI_t^i+B_t+B_{H,t}^*+\gamma_w/2(\pi_t^{w,i})^2P_t^CL_t+TAX_t.
\end{aligned}
\tag{4}
$$

The revenue side includes net nominal wage income $(1-\tau_t^w-\tau_t^{SCee})W_t^i$ adjusted by labor 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 country risk premium $-\omega\frac{B_{H,t-1}^*}{4P_{t-1}^YY_{t-1}}$ and the exogenous component ϵ_t^r, lump-sum transfers from the government TR_t, the return to capital $(1-\tau_t^k)i_t^kK_{t-1}^i$ net of capital taxes, depreciation allowances, and profit income from firm ownership PR_t. The expenditure side combines nominal consumption including taxes $P_t^CC_t^{NLC}$, nominal investment in the tradable and non-tradable sector $P_t^CI_t^i$, financial investment in domestic bonds and net foreign assets, quadratic adjustment costs γ_w for wages ($\pi_t^{w,i}=W_t^i/W_{t-1}^i-1$), and the non-distortionary lump-sum tax TAX_t.

LC households account for the share *slc* of population. Their period budget constraint 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 gives 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 ($Z^i_{T,t}$) and non-tradable ($Z^i_{NT,t}$) goods. Assuming the same price elasticity for consumption and investment demand, we can combine domestically produced tradables ($C^i_{TH,t}, I^i_{TH,t}$), non-tradables ($C^i_{NT,t}, I^i_{NT,t}$) and imported goods ($C^i_{TF,t}, I^i_{TF,t}$) to $Z_t \in (C_t^{NLC}, C_t^{LC}, I_t)$.

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

with ϕ and ν 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 elasticity of substitution between domestically produced goods and imports.

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

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

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

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

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 $K_{s,t-1}^j$, labor $L_{s,t}^j$ 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 $MC^j_{s,t}$ of the optimizing firm:

$$MC^j_{s,t} = \frac{(i^k_t)^\alpha[(1+\tau^{SCer}_t)W_t]^{1-\alpha}}{A_{s,t}\alpha^\alpha(1-\alpha)^{1-\alpha}}. \tag{13}$$

The firms in each sector s face quadratic price adjustment costs γ_p and prices $P^j_{s,t}$ to maximize the discounted expected profit. For each sector, firms profit maximization has the following form:

$$E_0\sum_{t=0}^{\infty}\beta_t\frac{\lambda^{NLC}_t}{\lambda^{NLC}_0}(\frac{P^j_{s,t}}{P_{s,t}}Y^j_{s,t} - \frac{1+\tau^{SCer}_t W^j_{s,t}}{P_{s,t}}L^j_{s,t} - \frac{\gamma_p}{2}(\pi^{p,j}_{s,t})^2 Y_{s,t}). \tag{14}$$

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

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

Government Sector

The government collects labor, 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:

$$\begin{aligned}&(\tau^w_t + \tau^{SCee}_t + \tau^{SCer}_t)W_tL_t + \tau^k_t(i^k_t - \gamma)K_{t-1} + \tau^c_t P^C_t C_t + (1-slc)TAX_t + B_t \\ &= P^G_t G_t + TR_t + (1+i_{t-1})B_{t-1}.\end{aligned} \tag{16}$$

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:

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

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

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

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:

$$B^*_{H,t} = (1 + i_{t-1})B^*_{H,t-1} + P^Y_t Y_t - P^C_t(C_t + I_t) - P^G_t G_t - P^Y_t ADC_t. \tag{22}$$

The current account equals the change in NFA positions:

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

3 Simulation

Figures 3-6 depict the effects of alternative shocks in order to illustrate the basic mechanisms with a focus on sudden stops of private capital inflows. The IRFs include a negative total factor productivity (TFP) shock, a negative risk premium shock, a negative credit constraint shock, and a positive government spending shock. Further shocks are discussed in the appendix including consumption preference as well as price and wage markup shocks (see **Table 1** for the calibrated version of the model). For each shock, we differentiate three cases,

I. a small open economy without financial frictions as a benchmark

II. two small open economies under financial frictions (equation (1)), namely

   (a) a country outside the euro area, i.e. with no access to public external finance,

   (b) an euro area Member State with access to public external finance via *TARGET2*.

Shocks like the negative TFP shock that are associated with a current account deficit obviously imply a concomitant deterioration in the NFA position. In the benchmark case of no financial frictions (I) the constraint on foreign borrowings is not binding and the respective Lagrange multiplier ψ_c is zero (**Figure 3**). To account for financial frictions and the specific institutional framework of euro and non-euro countries two modifications are necessary. Under financial frictions and no access to public external finance, i.e. the case of the BELL group (IIa), the negative NFA position causes a binding of the collateral constraint and private capital outflows as NLC consumers invest in foreign instead of domestic bonds. As TARGET2 financing is not available to these euro outsiders, *TARGET2* is set to zero. ψ_c becomes positive and acts like a premium on interest rates. In the case of the euro members GIP, (II.b) countries under financial stress due to capital outflows have access to public external finance, and thus we allow for positive *TARGET2*. However, these additional *TARGET2* liabilities in turn cause the risk premium on foreign debt to increase.

Figure 3 illustrates the effects of a temporary 2.5 percentage point decline in TFP relative to the rest of Monetary Union. In the benchmark case, price stickiness draws out the increase in domestic prices and the decrease in real interest rates with a (negatively) hump-shaped reaction of output, consumption and investment. The real appreciation leads to a negative current account over the medium term and a concomitant deterioration of the NFA position. Under financial frictions the drop of investment causes the collateral constraint to bind as indicated by the increasing Lagrange multiplier (premium) ψ_c (see equation (1)), which restricts the NFA position. In the BELL case of non-euro members the financing of domestic demand through private capital inflows dries up, fur-

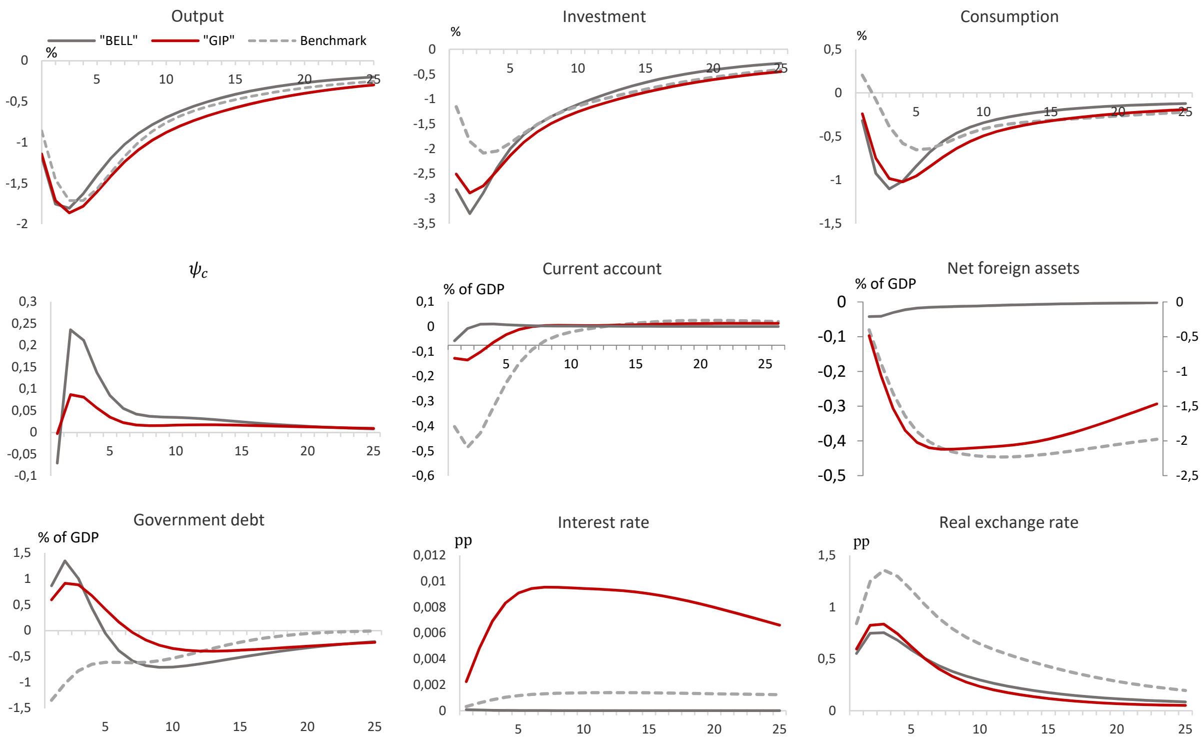

Figure 3: Sudden stop in response to a negative TFP shock

ther aggravating the fall in consumption and investment relative to the benchmark case. The drop in consumption and investment with its contemporaneous drop in tax revenues causes an increase of government debt that quickly levels off due to lower interest rate risk premia on the lower level of foreign debt. In contrast euro area Member States such as the GIP have access to TARGET2, and the inflow of public capital substitutes for the net outflow of private capital - the negative effects of the sudden stop are mitigated by public intervention. The associated increase in government debt is initially smaller due to the smaller loss in tax revenues but also more extended over time, as the weaker foreign debt position implies higher interest rate payments on sovereign bonds. Similar adjustments hold for consumption: households experience a sharper drop in consumption in the BELL case, but the recovery process evolves more quickly due to the lower interest burden. These differences in the adjustment process of GIP relative to BELL become more apparent, the longer the shock process lasts and the higher the risk premium on foreign debt ω is.

Figure 4 depicts the macroeconomic adjustments to a demand boom caused by a neg-

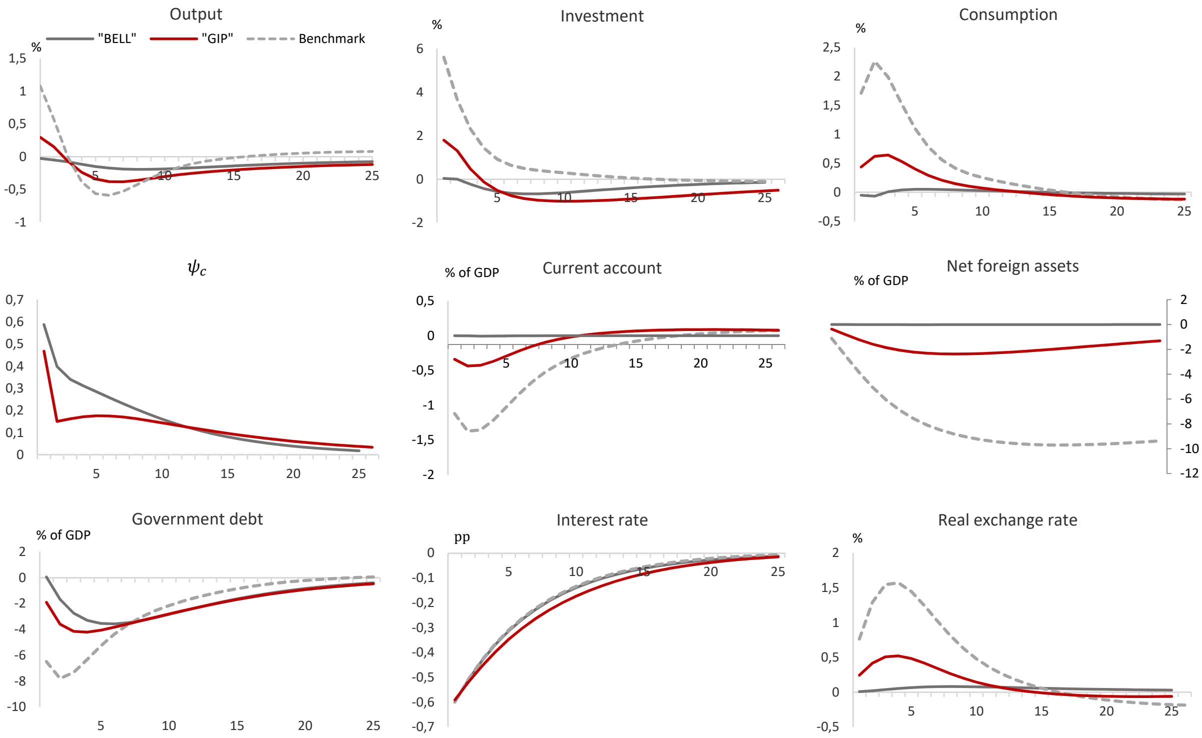

Figure 4: Sudden stop in response to a negative risk premium shock

ative risk premium shock, e.g. as investors become less risk-averse. In the benchmark case, the negative shock reduces borrowing rates, and real interest rates are even lower as inflation is drawn out due to nominal rigidities. With the concomitant real appreciation the current account and the NFA position deteriorate. Lower government borrowing costs and higher tax revenues reduce the government debt burden. Under financial frictions the credit constraint limits the deterioration of the NFA positions, and thus mitigates the subsequent need for macroeconomic adjustments. In the BELL case the effects on current account and the NFA are neutralized, while in the case of GIP the additional public capital flows cause a deterioration of the NFA position and allow for higher output and consumption levels as described in the benchmark case.

A positive government spending shock (see **Figure 5**) boosts output and consumption of

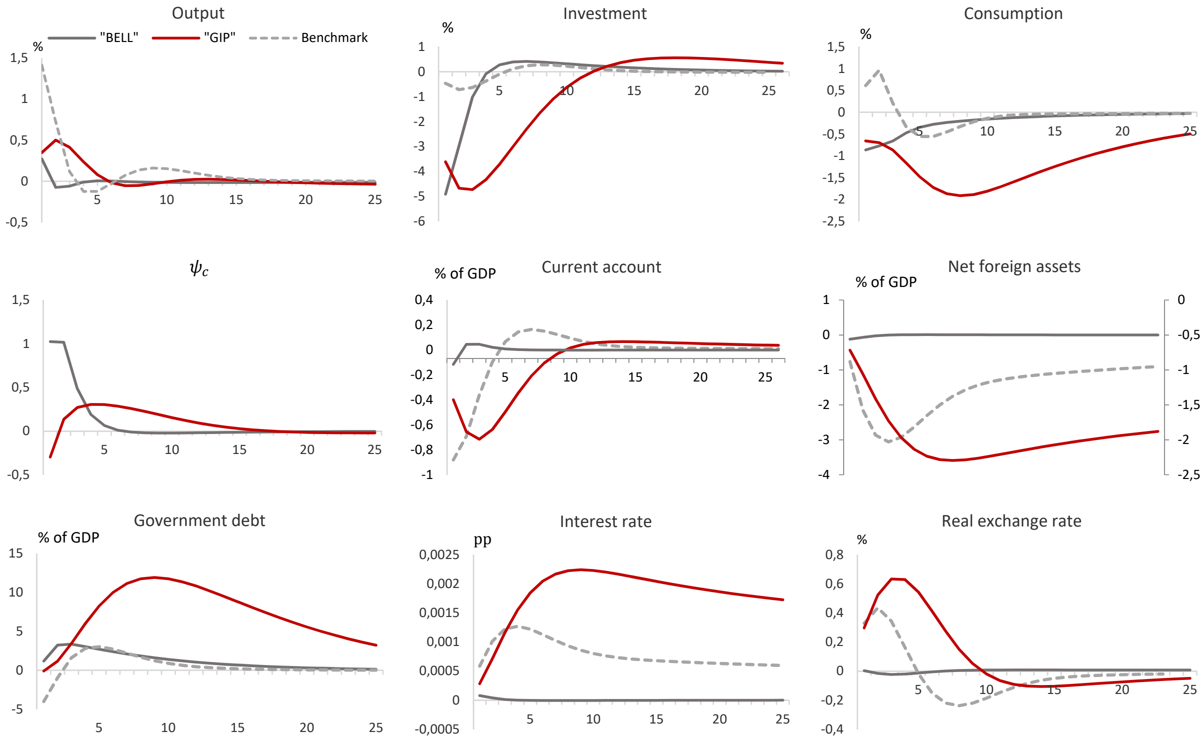

Figure 5: Sudden stop in response to a positive government shock

liquidity constraint households but also crowds out consumption and investment of NLC households due to higher interest rates. Inflationary periods due to higher demand cause a real exchange rate appreciation that contributes to higher interest rates and impairs the NFA position. Rising tax revenues delay the rise in government debt. The increase in government demand reduces net exports and the current account. However, with the increase in government debt the initial positive effects on output turn into the negative and reduce consumption of NLC and LC households. The decrease in consumption and output triggers deflationary processes that reduce the extend of the real appreciation and the negative NFA positions. In the BELL case, the credit constraint tightens, so that consumption and investment of NLC households decreases further which accelerates the adjustment process. With the availability of public external finance more net imports are possible (GIP). Subsequently, the degree of foreign indebtedness as well as the increase in interest rates due to higher risk premium on foreign debt are double the benchmark case, while leading to a prolonged fall in consumption and investment, and thus government debt.

A negative credit constraint shock (see **Figure 6**) eases financial frictions and allows for

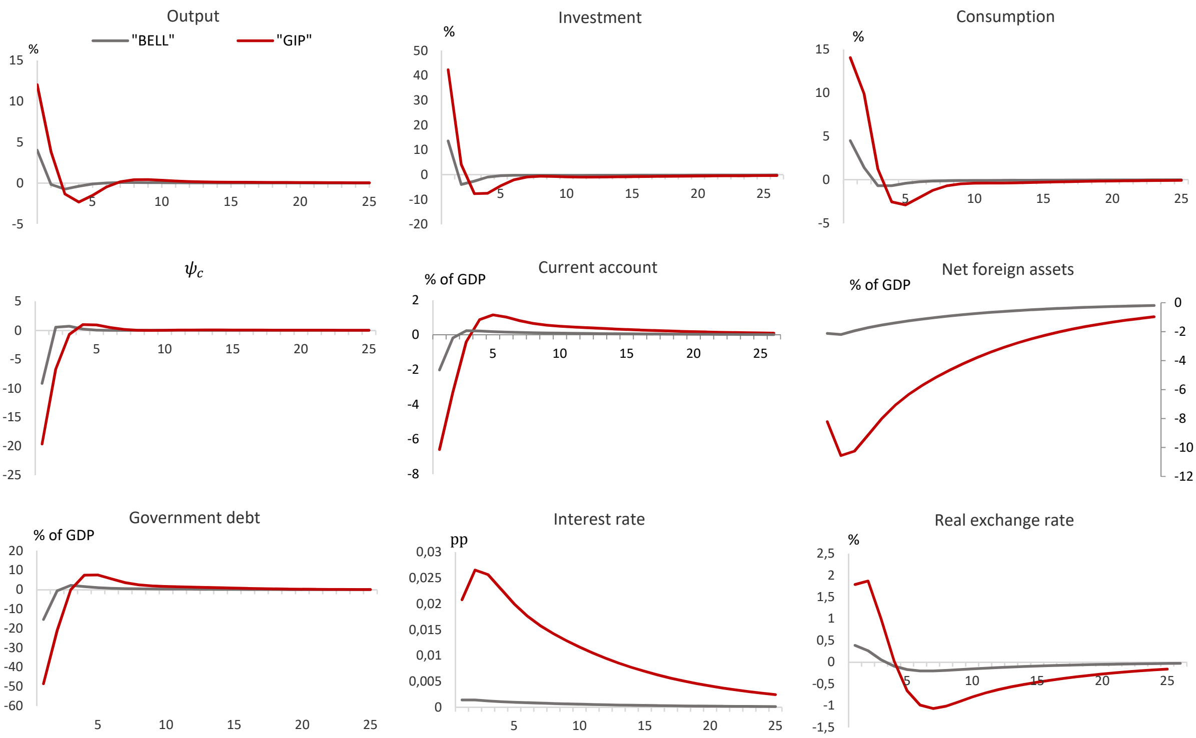

Figure 6: Sudden stop in response to a negative credit constraint shock

more foreign borrowing (starting from a balanced current account). Output, consumption and investment increase, while government debt declines. Initially, the real exchange rate appreciates and the current account deteriorates. As the credit constraint starts to bind, foreign indebtedness decreases and the real exchange depreciates (BELL case). Additional public capital flows allow for more extended external imbalances in the case of GIP. NFA positions deteriorate further, the real exchange rate appreciates, and the interest rate rises. The initial decrease in government debt reverses in the medium run. While the macroeconomic adjustments are qualitatively similar under the two regimes, the availability of public external finance implies much stronger imbalances and thus much more pronounced adjustment processes.[2]

While domestic shocks have negligible effects on the foreign economy, foreign shocks have significant effects on the domestic economy. Foreign risk premium shocks represent monetary policy shocks in the rest of the Monetary Union (GIP case) and monetary policy shocks of the Monetary Union (BELL case), respectively. They are transmitted to the domestic economy inclusive a risk premium on negative NFA positions. Thus, positive foreign risk premium shocks have a positive effect on domestic current account and NFA positions. An increase in foreign productivity decreases tradable relative to non-tradable goods prices, current account and NFA position deteriorate.

After having discussed the main relationships and differences of the various model versions with and without financial frictions as well as additional public loans, we estimate the model and evaluate the historical shock decompositions in order to further elaborate the characteristics of BELL and GIP and to relate these characteristics to our simulation findings.

[2]Due to sluggish price and wage adjustment, shocks to the capital market (credit constraint shocks, risk premium shocks) lead to an overshooting of real variables like output and consumption: the downward adjustment of prices and wages is delayed when investment and consumption decrease. This holds particularly the case of real variables in GIP.

4 Estimation

Following Schorfheide (2000) and Schorfheide and Lubik (2003), we apply a two-step estimation procedure involving calibration and Bayesian techniques in order to model two versions of a small open economy with financial frictions, i.e. BELL and GIP. We use quarterly data for GIP and BELL from 2003Q1 to 2013Q4, including real GDP and consumption, hours worked, investment, CPI inflation, long term interest rates, real exchange rates, government expenditure and current account. Public capital flows in form of TARGET2 data replace private capital flows when the credit constraint binds. We add several shocks to the model, namely domestic and foreign TFP, domestic and foreign risk premium, credit constraint, consumption, government spending, price and wage markup shocks. The period 2003Q1 to 2013Q4 was chosen as it covers the sudden stop (starting in 2007) and the different adjustment processes in both regions after the financial crisis while avoiding possible disturbing effects in later periods when the Baltic countries subsequently joined the euro area.

Calibration and prior specification

We calibrate the values for the discount factor, steady state ratios of the model, such as consumption, investment and government spending shares on the basis of national accounts data for the euro area, the share of LC households, the capital share, and tax rates. The calibrated parameters are summarized in **Table 1**.

The steady-state ratios are calibrated to replicate the average share of private consumption, investment and government purchases in the euro area GDP during the estimation period. The corresponding values for the group of Bulgaria, Estonia, Latvia and Lithua-

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
α	Cobb-Douglas parameter (capital share)	0.4
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	labor 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

nia diverge only slightly by $1-2\%$. 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.

The average tax rate on consumption (VAT rate) and capital income is 19.7% (European Commission, 2013) and 30% (OECD Tax Database), respectively. The average labor income tax burden for the given period is 16% of total earnings plus 13% social security contribution (SSC) for the households. 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), accordingly.

We follow Adolfson et al. (2007) in choosing prior distribution. The prior and posterior estimates for the benchmark models are displayed in **Tables 2-3**.[3]

Columns 3-5 of **Tables 2-3** depict our assumptions for the means, standard deviations,

[3] In order to save space, we present the estimated parameters standard deviation and measurement error for the shock processes in the appendix.

Table 2: Estimation results: GIP

		Prior			Posterior max.		Metropolis-Hastings		
Param	description	Type	Mean	sd.	mode	sd.	Mean	90% HPD interval	
ω	Country risk premium	Norm	0.0025	0.001	0.0035	0.0008	0.0048	0.0012	0.0084
σ	Inverse of intertemp. elast. of subst.	Norm	1.5	0.2	1.4520	0.1727	1.4828	1.2090	1.7759
η	Trade elast. between home/foreign	Norm	1.5	0.2	2.3159	0.1545	2.2837	2.0293	2.5488
ν	Elasticity of substitution T/NT	Gamma	0.5	0.1	0.3588	0.0719	0.3924	0.2608	0.5251
ϵ	Elasticity of goods varieties j	Gamma	6.0	0.75	5.7544	0.7199	4.9166	2.9202	7.5769
h	Degree of home bias	Beta	0.5	0.1	0.1695	0.0387	0.1795	0.1144	0.2428
$1-\chi$	Credit constraint	Gamma	0.1	0.02	0.1053	0.0214	0.1087	0.0727	0.1424
ϕ	Share of tradable goods consumption	Beta	0.6	0.2	0.6644	0.0230	0.6688	0.6185	0.7100
κ	disutility of work	Beta	1	0.1	0.9108	0.0964	0.9268	0.7693	1.0807
φ	Inverse of elast. of labor	Beta	4	1	5.8544	0.9845	6.9197	4.9746	8.7428
γ_w	Wage adjustment costs	Beta	80	20	79.91	19.93	73.87	35.54	109.48
γ_p	Price adjustment costs	Beta	48	10	47.19	10.45	39.38	25.44	52.86
ρ_a	Persistence of TFP shock	Beta	0.7	0.1	0.8761	0.0347	0.8652	0.8045	0.9304
ρ_c	Persistence of consumption shock	Beta	0.7	0.1	0.7719	0.0695	0.7488	0.6398	0.8617
ρ_{rp}	Persistence of risk premium	Beta	0.7	0.1	0.9661	0.0121	0.9633	0.9461	0.9790
ρ_χ	Persistence credit constraint	Beta	0.7	0.1	0.9185	0.0285	0.9036	0.8531	0.9541
ρ_g	Persistence of government spending	Beta	0.7	0.1	0.7326	0.0761	0.7181	0.5948	0.8379
ρ_{afor}	Persistence of TFP shock foreign	Beta	0.7	0.1	0.7248	0.1050	0.8652	0.5358	0.8629
ρ_{rpfor}	Persistence of risk premium foreign	Beta	0.7	0.1	0.7265	0.1046	0.6973	0.5264	0.8621
ρ_{γ_w}	Persistence wage markup	Beta	0.7	0.1	0.7271	0.1045	0.7138	0.5778	0.8513
ρ_{γ_p}	Persistence price markup	Beta	0.7	0.1	0.8522	0.0600	0.7740	0.6262	0.9287
Marginal likelihood (Laplace approximation)		1161.66							
Marginal likelihood (Harmonic mean)		1164.31							
Average acceptance rate for each chain		0.32	0.31						

Table 3: Estimation results: BELL

		Prior			Posterior max.		Metropolis-Hastings		
Parameter	description	Type	Mean	sd.	mode	sd.	Mean	90% HPD interval	
ω	Country risk premium	Norm	0.0025	0.001	0.0020	0.0010	0.0040	0.0020	0.0000
σ	Inverse of intertemp. elast. of subst.	Norm	1.5	0.2	1.9418	0.1593	1.9673	1.7189	2.2106
η	Trade elast. between home/foreign	Norm	1.5	0.2	1.5491	0.1993	1.6205	1.3417	1.9220
ν	Elasticity of substitution T/NT	Gamma	0.5	0.1	0.4727	0.0969	0.4867	0.3386	0.6492
ϵ	Elasticity of goods varieties j	Gamma	6.0	0.75	5.4100	0.6910	5.9147	4.7330	7.0416
h	Degree of home bias	Beta	0.5	0.1	0.2276	0.0506	0.1957	0.1202	0.2698
$1-\chi$	Credit constraint	Gamma	0.1	0.02	0.1087	0.0219	0.1137	0.0777	0.1492
ϕ	Share of tradable goods consumption	Beta	0.6	0.1	0.7876	0.0553	0.8364	0.7593	0.9066
κ	disutility of work	Gamma	1	0.4	0.8379	0.3656	0.9940	0.3842	1.5962
φ	Inverse of elast. of labor	Gamma	4	1	3.3139	0.8602	3.9036	2.4321	5.2777
γ_w	Wage adjustment costs	Gamma	80	20	80.0940	16.8240	84.6773	53.6711	113.8476
γ_p	Price adjustment costs	Gamma	48	10	48.0497	9.4889	52.7851	36.5672	68.7324
ρ_a	Persistence of TFP shock	Beta	0.7	0.1	0.8690	0.0394	0.8427	0.7740	9123
ρ_c	Persistence of consumption shock	Beta	0.7	0.1	0.7024	0.0839	0.6822	0.5434	0.8402
ρ_{rp}	Persistence of risk premium	Beta	0.7	0.1	0.9536	0.0140	0.9542	0.9339	0.9745
ρ_χ	Persistence credit constraint	Beta	0.7	0.1	0.9206	0.0241	0.9084	0.8640	0.9544
ρ_g	Persistence of government spending	Beta	0.7	0.1	0.7148	0.0989	0.7063	0.5567	0.8508
ρ_{afor}	Persistence of TFP shock foreign	Beta	0.7	0.1	0.7222	0.1056	0.6989	0.5429	0.8634
ρ_{rpfor}	Persistence of risk premium foreign	Beta	0.7	0.1	0.7222	0.1056	0.7039	0.5475	0.8646
ρ_{γ_w}	Persistence wage markup	Beta	0.7	0.1	0.7249	0.1059	0.7304	0.6113	0.8489
ρ_{γ_p}	Persistence price markup	Beta	0.7	0.1	0.8243	0.0817	0.7090	0.5633	0.8720
Marginal likelihood (Laplace approximation)		934.25							
Marginal likelihood (Harmonic mean)		936.78							
Average acceptance rate for each chain		0.30	0.29						

and the underlying distributions of the priors. The prior means are mainly based on calibrated parameter values used by Hohberger et al. (2014). 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 percent in the NFA-to-GDP position with a corresponding increase of the annualized borrowing rate. According to Druant et al. (2012), we set the wage and price adjustment cost parameters γ_w and γ_p to 80 and 48 such that wage adjustments by 1 percent cost 0.40 percent of GDP and price adjustments by 1 percent cost 0.25 percent of GDP, respectively. The prior mean of each shock persistence parameter is set to 0.7 with a standard deviation of 0.1. The value of the prior mean lies in the range of 0.5 and 0.8, as suggested by Marcellino and Rychalovska (2012) and Justiniano and Preston (2010). In order to estimate the standard deviation of shocks and the measurement errors, inverse gamma distributions with prior means of 0.01 and standard deviations of 0.01 are specified. Similar values can be found in Almeida (2009), who set the prior means equal to the standard deviations to form uninformative priors.

We run 100,000 draws with two distinct chains, using the Metropolis-Hastings algorithm. To account for any dependence of the chains from its starting values, the first 50 percent are dropped as burn (Röhe, 2012). Results from posterior and Metropolis-Hastings estimation are shown in the last five columns of **Tables 2-3**, including the Highest Posterior Density Interval (HPDI)[4].

In order to evaluate our estimation and to check for robustness and sensitivity, we esti-

[4]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)).

mate the models with different prior specifications. Following Almeida (2009), we test for loose prior standard deviations (10 and 25 percent plus on initial standard deviation) and initial prior means. While in the former case some posterior means show higher sensitivity than in the latter case, the estimation results are robust. Additionally, the results are robust to changes in the prior specification and changes in the estimation period to 2005Q1 to 2013Q4 and to 2003Q1 to 2015Q1. Moreover, all parameters are identified. [5]

5 Results

Parameter Estimates

Comparing the posterior estimates of GIP and BELL, the endogenous part of the risk premium ω increases with the provision of public capital flows. Accordingly, the lower capacity of foreign indebtedness improves the risk premium on interest rates. The credit constraint $(1-\chi)$ relates foreign indebtedness to domestic investments. A posterior mean value of 0.1137 for the credit constraint parameter in BELL reduces foreign indebtedness to around 11 percent of domestic investment relative to GDP. In case of GIP, TARGET2 balances allow for additional foreign indebtedness after a tightening of private capital inflows to a quite similar degree, namely 10.9 percent of investment relative to GDP.

Wage adjustment costs are borne by households as wages are set by labor unions. Households in BELL face higher adjustment costs than their euro area counterparts, possibly reflecting lower power of labor unions. Additionally, higher posterior mean values for price adjustment costs in BELL relative to GIP further strengthen the negative effects of

[5] Under application of Ratto and Iskrev (2010a) and Ratto and Iskrev (2010b).

a sudden stop.

Highlighting the effect of a sudden stop on the export and import sector, BELL is characterized by a larger share of tradable goods in consumption combined with a lower trade elasticity between home and foreign (see also Gros and Alcidi, 2014).

Considering shock process estimates, risk premium shocks are more dominant in GIP in case of amplitude as well as persistence, while BELL is more affected by foreign risk premium shock from the euro area. In case of TFP shocks and shocks to price adjustment costs, posterior estimates show a higher standard deviation in BELL, but those shocks are more persistent in GIP. The same holds for government spending.

Historical shock decomposition

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

Figure 7-9 plot the historical shock decomposition for output, consumption and current account relative to GDP in both regions. The solid line depicts the smoothed value of the deviation of a variable's historic value from its steady state, whereas the vertical bars show the contribution of the different smoothed shocks to the development of the variable.

First, the historical shock decomposition indicates that TFP and collateral constraint shocks had a noticeable impact in both regions. While the negative effects in GIP lasted until the end of the estimation period, the recovery process in BELL started already in 2011. Domestic risk premium shocks played a major role in the build-up of the financial crisis in GIP, whereas in BELL foreign risk premium shocks were more relevant. Foreign

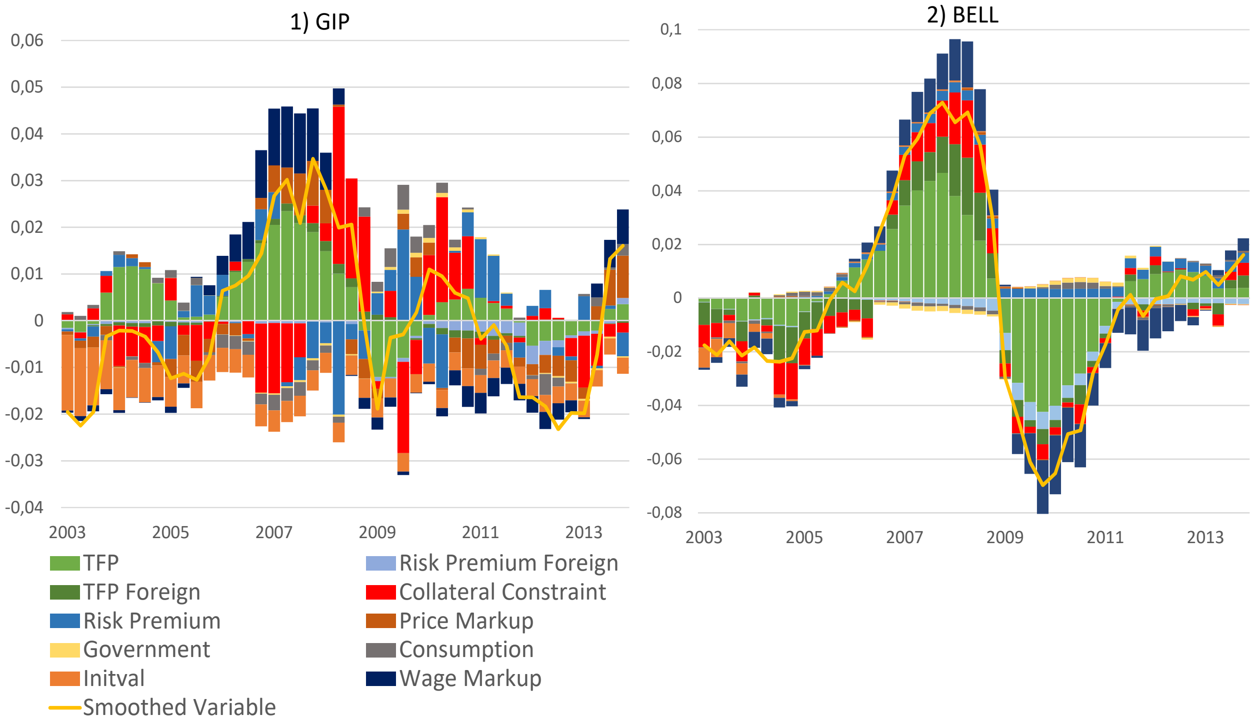

Figure 7: Historical shock decomposition Output

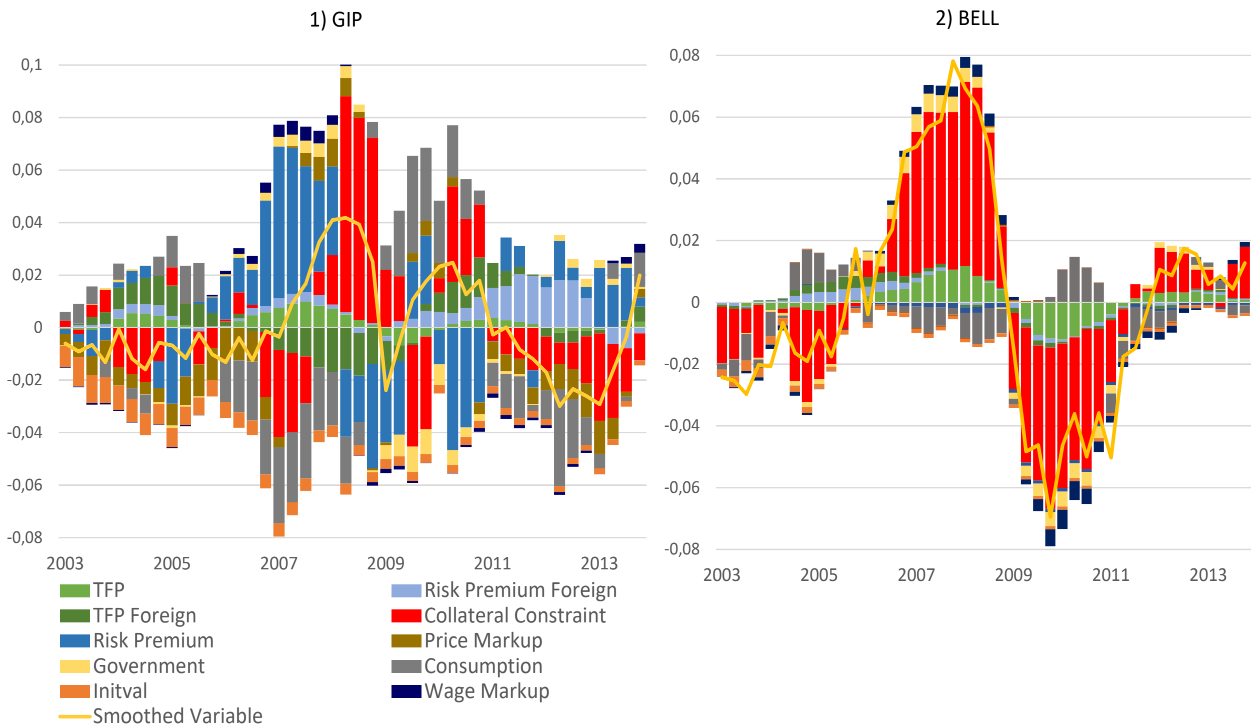

Figure 8: Historical shock decomposition Consumption

TFP shocks were important for GIP developments but almost negligible in BELL with the exception of output. In general, shock contributions to smoothed data varies widely between the two groups of countries. For BELL, the historical decomposition indicates the presence of mainly pro-cyclical shocks to smoothed data. In the case of GIP, the evidence is more ambiguous and shocks contribute more persistently as can be seen for TFP, consumption, government spending and wage markup shocks.

Domestic and foreign TFP shocks

In both regions, TFP shocks had a noticeable effect on output throughout the whole sample. BELL suffered to a large extent from a decrease in productivity between 2008 and 2011 when the financial crisis was still unfolding. In contrast, the productivity decrease in GIP was less severe but persisted until the end of the estimation period in 2013. This might be attributable to the aftermath of the financial crisis that gave way to the banking and sovereign debt crisis in the euro area. Additionally, foreign TFP shocks in the rest of euro area contributed negatively to GIP consumption and current account between 2007 and 2009, while having hardly any effect on BELL.

Domestic and foreign risk premium shocks

In the GIP case, the positive effect of a declining domestic risk premium becomes apparent in the build up of the financial crisis as lower borrowing costs boosted goods demand and particularly household consumption (see also **Figure 4**) . The subsequent drop in consumption in 2009 is related to the reversal of risk premium shocks. At that time, peripheral countries experienced a sudden increase in risk premium on sovereign debt (see also Gourinchas et al., 2016). Furthermore, due to TARGET2 flows and higher risk premium on interest rates, the positive effect of negative risk premium shocks on output and

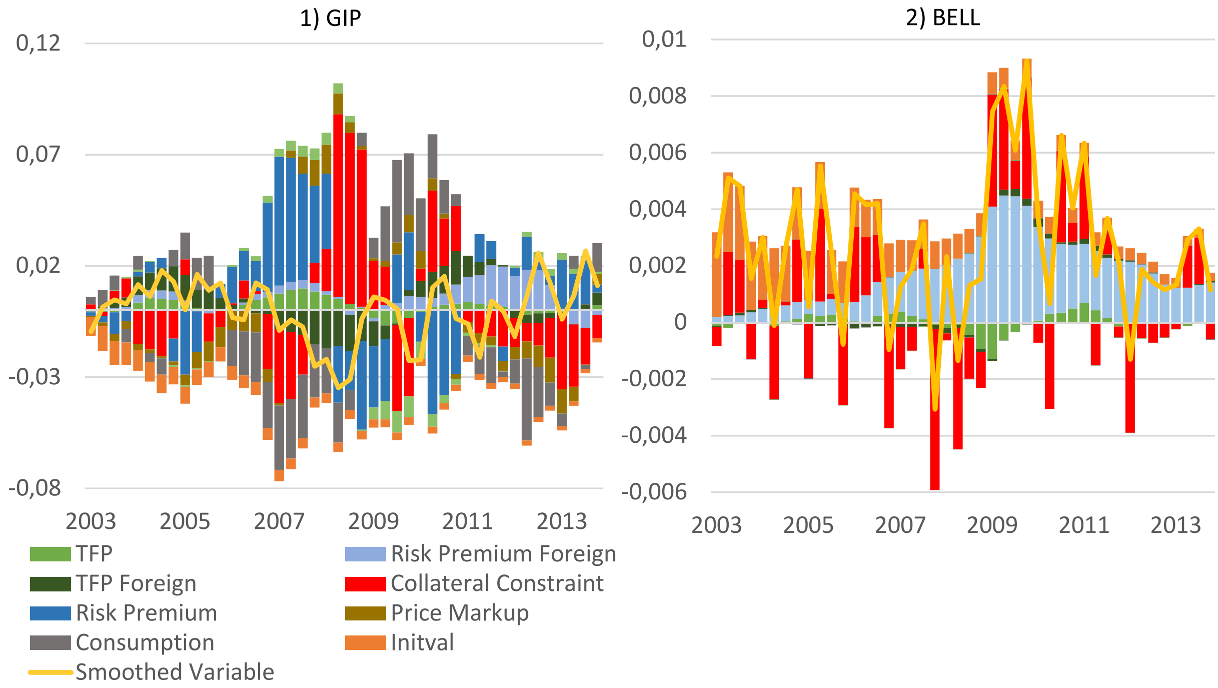

Figure 9: Historical shock decomposition Current Account

consumption quickly leveled off and even the respective variables to invert (**Figure 4**). This effect becomes evident in the negative contribution of risk premium shocks in 2008 and 2010. The influence of foreign risk premium shocks from the rest of the euro area to GIP is significant only from 2010 onwards, whereas a positive impact of such foreign risk premium shocks accounts for most of the current account development in BELL. As BELL is typically characterized by rather negative NFA positions with respect to the euro area, an increase in the current account due to foreign risk premium shocks is likely to arise out of higher consumption and investment demand in euro area rather than capital exports from BELL.

Credit constraint shocks

As illustrated in **Figure 5**, negative shocks to the collateral constraint initially increase output and consumption. However, this increase turns into a decline which in the case of

GIP is on the one hand delayed due to TARGET2 flows and on the other hand intensified due to the higher risk premium on the deteriorated NFA positions. The effect of tightening and relaxing credit constraints is ever present and persistent in BELL, replicating the smoothed data movement, whereas in GIP this effect on output, consumption and current account is rather erratic, contributing positively in 2007-2008 and 2010-2011 and negatively in 2009 and from 2011 onwards. It seems natural to relate this evidence to the events of the financial crisis: In 2009, private capital dried up while public capital only began to set in; in 2012, the ECB started its asset purchasing programs (see also Gros and Alcidi, 2014).

Consumption and price markup shocks

Consumption and price markup shocks seem to have contributed to a recovery in GIP which was much delayed relative to BELL. Since consumption as well as price markup shocks positively correlate with output, consumption and current account (see **Figure 10 & 11**), the negative effects on the respective variables from 2011 onwards can be ascribed to a decrease in consumption and a dampening effect on the downward pressure on prices in the euro area periphery (see also Gilchrist et al., 2015).

Wage markup shocks

The shock decomposition indicates large-scale wage markup shocks that contribute procyclically to output in BELL throughout the estimation period. In the case of GIP, the positive effects in the pre-crisis years between 2006 and 2008 appear to be the most dominant ones.

In sum, countries inside Monetary Union bear a higher risk premium on foreign indebtedness in the long run as they do not have a restriction on NFA positions due to TARGET2 balances. While from 2009 to 2011 TFP shocks, credit constraint shocks and wage markup shocks seem to be the main drivers for the decline in output and consumption in BELL, GIP is characterized by the positive impact of public capital inflows when the credit constraint binds. However, that effect is of a temporary nature only as the negative effects of mainly credit constraint, consumption and price markup shocks led to an delayed and extended decrease in output and consumption from 2011 onwards.

6 Conclusion

This paper uses a two-sector model with two regions to analyze the differences in the adjustment processes in case of a sudden stop of private capital inflows. We contribute to the existing literature by (i) modeling sudden stops of private capital inflows for two types of monetary and exchange rate regimes, namely an economy that is pegged to the euro and an economy that is member of the currency union with automatic access to public external finance, and (ii) estimating the model for two representative groups of countries, namely Greece, Ireland, and Portugal as euro insiders as well as Bulgaria, Estonia, Latvia, and Lithuania as euro outsiders that pursue a strict euro peg. Our analysis points to a severe long run vs. short run trade-off that characterizes the adjustment to sudden stops for these two types of monetary regimes. TARGET2 access is advantageous in the short run as it helps to mitigate the negative output effects of the reversals in capital flows, however in the long run it leaves countries worse off, not the least due to an increased debt burden.

As the experience in the euro area after 2011 indicates, these negative long run effects can have very severe repercussions ranging from the possibility of countries leaving the euro area to the risk of an outright euro area break up. In particular, an adequate consideration should be given to possible political constraints to TARGET2 financing.[6] As recent experiences indicate, political support in the surplus countries for the euro project is likely to disappear with an excessive use of TARGET2 credit. In this situation it might be helpful and even imperative to disincentivize the use of TARGET2 financing, e.g. by risk adjusting interest rates, and establish/strenghten alternative adjustment mechanisms, e.g. a fiscal policy rule that reacts to foreign debt burdens. Alternatively, providing a mechanism for an orderly exit from the euro area might be called for.

[6] see Steiner et al. (2017) for possible limits on TARGET2 balances

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A Impulse Responses

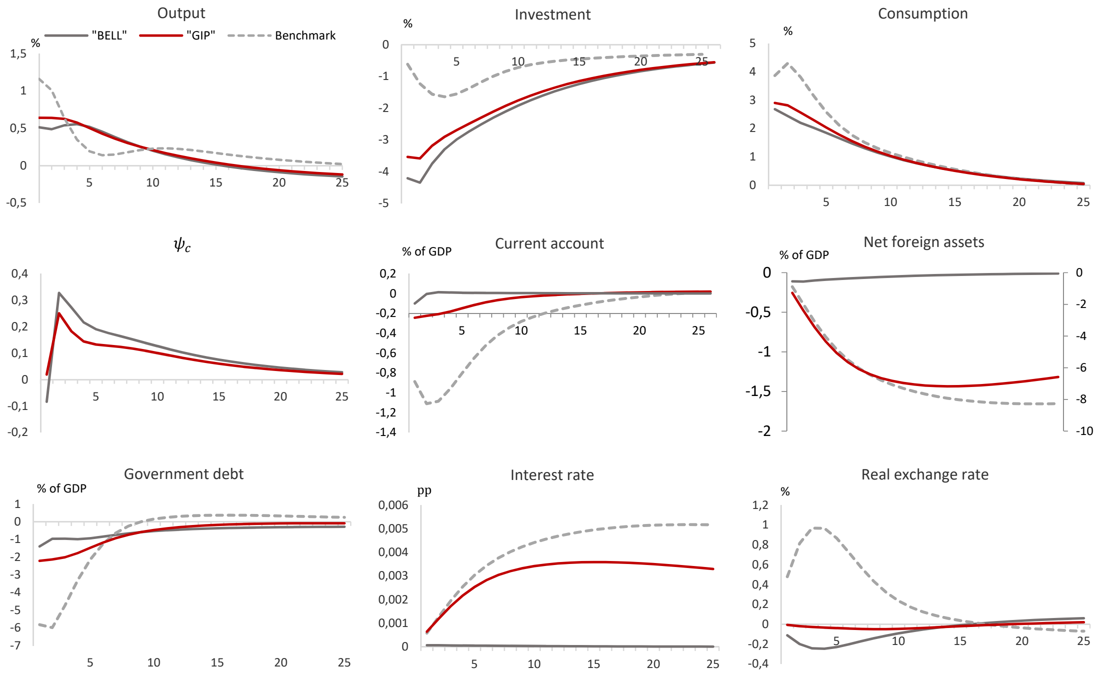

Figure 10: Sudden stop in response to a positive consumption preference shock

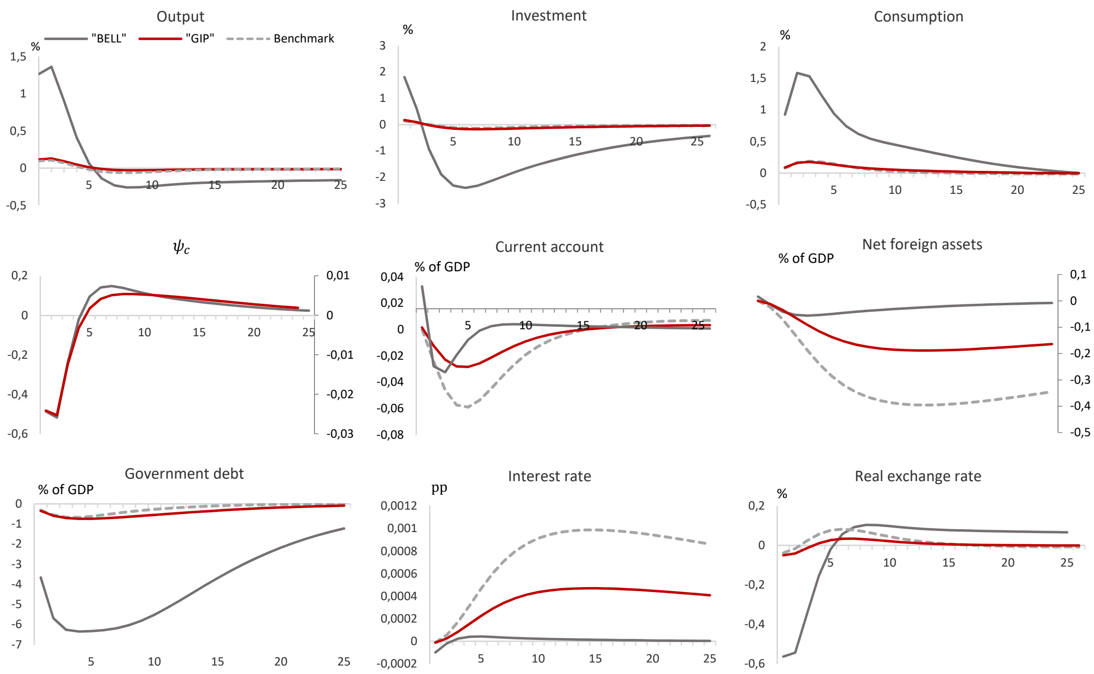

Figure 11: Sudden stop in response to a negative price markup shock

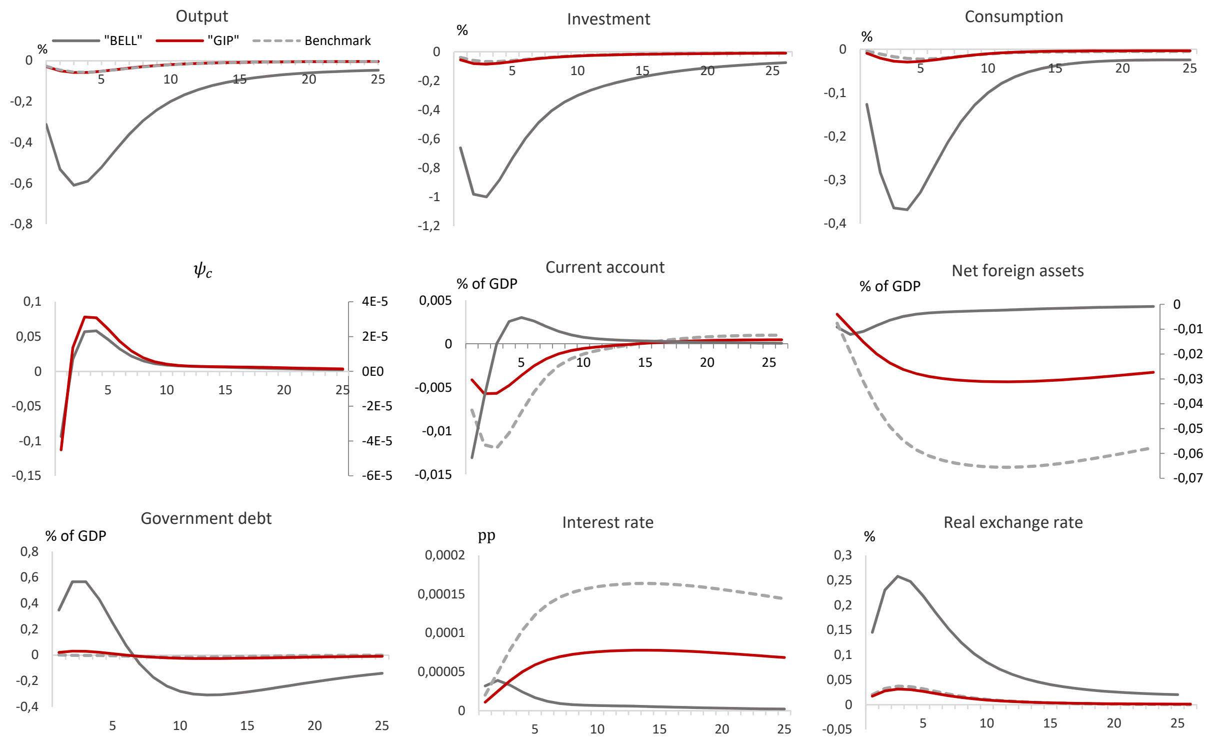

Figure 12: Sudden stop in response to a positive wage markup shock

B Data and Sources

Since we distinguish between countries pegged to the Euro and countries inside the Euro are, data for the peggers is obtained by aggregating data for Bulgaria, Estonia, Latvia and Lithuania and for the euro area periphery by combining data of Greece, Ireland and Portugal. We depart from including Spain as it does not really fit the features of a small euro area country and has a rather dominant construction sector. All data is seasonally and calendar adjusted and demeaned.

real GDP Nominal GDP at current market prices. Source: Eurostat (*namq_10_gdp*).

real consumption Final consumption expenditure of households. Source: Eurostat (*namq_10_gdp*).

hours worked Thousand hours worked in all economic sectors (NACE Rev.2). Source:

Eurostat (*namq_10_gdp*).

investment Gross capital formation by households. Source: Eurostat (*namq_10_gdp*).

CPI inflation Implicit price deflator 2010=100. Source: Eurostat (*namq_10_gdp*).

interest rates Government bonds (including risk premium). Source: International Financial Statistics.

real exchange rates Deflator of BELL (GIP) relative to (rest of) Euro are Deflator. Source: Eurostat.

government expenditure Total general government spending in Millions Euro at current market prices. Source: National Statistics.

current account Current account balance total economy, except from the period 2003-2006 for Bulgaria where current account data was taken from balance of payments and interpolated to quaterly data. Source: Eurostat (*namq_10_gdp*).

TARGET2 data Monthly data on TARGET2 balances converted into quarterly data. Source: ECB's Statistical Data Warehouse.

C Shock Processes

All shocks evolve according to:

$$\epsilon_t^a = \rho_a \epsilon_{t-1}^a + \sigma_a$$

$$\epsilon_t^c = \rho_c \epsilon_{t-1}^c + \sigma_c$$

$$\epsilon_t^{rp} = \rho_{rp} \epsilon_{t-1}^{rp} + \sigma_{rp}$$

$$\epsilon_t^{\chi} = \rho_{\chi} \epsilon_{t-1}^{\chi} + \sigma_{\chi}$$

$$\epsilon_t^g = \rho_g \epsilon_{t-1}^g + \sigma_g$$

$$\epsilon_t^{afor} = \rho_{afor} \epsilon_{t-1}^{afor} + \sigma_{afor}$$

$$\epsilon_t^{rpfor} = \rho_{rpfor} \epsilon_{t-1}^{rpfor} + \sigma_{rpfor}$$

$$\epsilon_t^{\gamma_w} = \rho_{\gamma_w} \epsilon_{t-1}^{\gamma_w} + \sigma_{\gamma_w}$$

$$\epsilon_t^{\gamma_p} = \rho_{\gamma_p} \epsilon_{t-1}^{\gamma_p} + \sigma_{\gamma_p}$$

Additional estimation results of the shock processes:

Table 4: Estimation results: GIP

		Prior			Posterior max.		Metropolis-Hastings		
Param	description	Type	Mean	sd.	mode	sd.	Mean	90% HPD interval	
σ_a	Std dev TFP	InvG	0.01	0.01	0.0068	0.0010	0.0070	0.0053	0.0087
σ_{rp}	Std dev risk premium	InvG	0.01	0.01	0.0162	0.0032	0.0185	0.0126	0.0240
σ_χ	Std dev credit constraint	InvG	0.01	0.01	0.1609	0.0175	0.1637	0.1346	0.1921
σ_g	Std dev gov spending	InvG	0.01	0.01	0.0089	0.0016	0.0095	0.0066	0.0122
σ_{rpfor}	Std dev risk premium foreign	InvG	0.01	0.01	0.0217	0.0029	0.0234	0.0181	0.0240
σ_{afor}	Std dev TFP foreign	InvG	0.01	0.01	0.0170	0.0032	0.0170	0.0053	0.0238
σ_c	Std dev consumption	InvG	0.01	0.01	0.0250	0.0046	0.0278	0.0194	0.060
σ_w	Std dev wage markup	InvG	0.01	0.01	0.0058	0.0022	0.0688	0.0029	0.1393
σ_p	Std dev price markup	InvG	0.01	0.01	0.0381	0.0079	0.0241	0.0033	0.0458
σ_{yobs}	Std dev measurement shock Y	InvG	0.01	0.01	0.0041	0.0004	0.0043	0.0030	0.0055
σ_{cobs}	Std dev measurement shock C	InvG	0.01	0.01	0.0046	0.0010	0.0051	0.0026	0.0070
$\sigma_{\pi obs}$	Std dev measurement shock π	InvG	0.01	0.01	0.0042	0.0007	0.0046	0.0031	0.0060
σ_{rerobs}	Std dev measurement shock rer	InvG	0.01	0.01	0.0045	0.0006	0.0049	0.0035	0.0064
σ_{ca}	Std dev measurement shock CA	InvG	0.01	0.01	0.0106	0.0014	0.0108	0.0085	0.0132
σ_{intobs}	Std dev measurement i	InvG	0.01	0.01	0.0038	0.0007	0.0042	0.0028	0.0056
σ_{gobs}	Std dev measurement G	InvG	0.01	0.01	0.0026	0.0003	0.0027	0.0021	0.0122

Table 5: Estimation results: BELL

		Prior			Posterior max.		Metropolis-Hastings		
Parameter	description	Type	Mean	sd.	mode	sd.	Mean	90% HPD interval	
σ_a	Std dev TFP	InvG	0.01	0.01	0.0111	0.0013	0.0112	0.0091	0.0133
σ_{rp}	Std dev risk premium	InvG	0.01	0.01	0.0015	0.0032	0.0063	0.0032	0.0091
σ_χ	Std dev credit constraint	InvG	0.01	0.01	0.1299	0.0159	0.1348	0.1049	0.1656
σ_g	Std dev gov spending	InvG	0.01	0.01	0.0059	0.0023	0.0110	0.0038	0.0177
σ_{rpfor}	Std dev risk premium foreign	InvG	0.01	0.01	0.0025	0.0029	0.0166	0.0125	0.0208
σ_{afor}	Std dev TFP foreign	InvG	0.01	0.01	0.0046	0.0012	0.0057	0.0032	0.0081
σ_c	Std dev consumption	InvG	0.01	0.01	0.0287	0.0052	0.0227	0.0108	0.0338
σ_w	Std dev wage markup	InvG	0.01	0.01	0.0058	0.0022	0.1005	0.0660	0.1362
σ_p	Std dev price markup	InvG	0.01	0.01	0.0245	0.0068	0.0084	0.0032	0.0142
σ_{yobs}	Std dev measurement shock Y	InvG	0.01	0.01	0.0040	0.0006	0.0042	0.0030	0.0052
σ_{cobs}	Std dev measurement shock C	InvG	0.01	0.01	0.0064	0.0016	0.0076	0.0047	0.0106
$\sigma_{\pi obs}$	Std dev measurement shock π	InvG	0.01	0.01	0.0227	0.0026	0.0221	0.0175	0.0265
σ_{rerobs}	Std dev measurement shock rer	InvG	0.01	0.01	0.0304	0.0038	0.0336	0.0268	0.0403
σ_{ca}	Std dev measurement shock CA	InvG	0.01	0.01	0.0210	0.0023	0.0221	0.0175	0.0262
σ_{intobs}	Std dev measurement i	InvG	0.01	0.01	0.0031	0.0005	0.0034	0.0024	0.0043
σ_{gobs}	Std dev measurement G	InvG	0.01	0.01	0.0131	0.0015	0.0125	0.0098	0.0153
σ_{nobs}	Std dev measurement G	InvG	0.01	0.01	0.0050	0.0014	0.0053	0.0031	0.0074
σ_{invobs}	Std dev measurement G	InvG	0.01	0.01	0.0059	0.0023	0.0098	0.0033	0.0173