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Getting into *GEAR*: German and the Rest of Euro Area Fiscal Policy During the Crisis[☆]

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Abstract

In this paper, we use the estimated three-region DSGE model *GEAR*, which pictures Germany, the *Euro Area* and the *Rest of the world* and which is used by the Deutsche Bundesbank for policy analysis, to analyze how discretionary fiscal policy in Germany and the rest of EMU affected GDP growth and unemployment during the crisis. Not surprisingly, stimulus programmes positively affected domestic GDP growth rates while consolidation measures had a negative impact. The contribution of fiscal policy on domestic GDP growth was only small, however, amounting to a maximum of 1.6% for Germany and 0.8% for the rest of the Euro Area in terms of annualized quarter-on quarter growth rates. The main driver for the evolution of GDP were rest of the world and risk premia shocks, followed by domestic non-fiscal shocks, amongst them the technology shock being the most important one. Spillovers of fiscal policy shocks are negligibly small, which holds for spillovers of fiscal shocks in Germany to the rest of the Euro Area and vice versa. This latter finding is confirmed by an impulse-response analysis and by calculating the corresponding multipliers. Hence, relating these findings to current discussions, our analysis suggests that domestic fiscal policy has little effects on the other regions' GDP within EMU and can, therefore, contribute only little to solving the imbalances problem.

Keywords: Fiscal Policy, Unemployment, DSGE modeling, Bayesian estimation (JEL: H2, J6, E32, E62)

1. Introduction

Because of the recent financial crisis governments around the world have put in place ambitious fiscal stimulus packages more or less starting mid 2008. Many of those

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ambitions, however, forced fiscal authorities to start consolidating shortly after stimulating the economy to ensure stability of public finances. Germany, as one of the few exemptions perhaps, suffered relatively little in terms of dampened GDP growth and economic activity compared to, in particular, other countries within the European Monetary Union (EMU). To quantify the role of fiscal policy for these developments, we present a large-scale dynamic stochastic general equilibrium (DSGE) model with three blocks of countries in which two of them form a monetary union.

To be more specific, the model we use in this paper is *GEAR*: an estimated three-region DSGE model of Germany, the rest of the Euro Area and the Rest of the world. We apply historical shock decompositions and impulse response functions to assess how responsible discretionary fiscal policy is for the evolution of GDP growth and unemployment rates, and how much of it spilled over to other regions during the recent crisis. We also calculate the size of fiscal multipliers in our model. The core of our model comprises the well-known DSGE model of Smets and Wouters (2003, 2007) or Christiano et al. (2005), which we extend substantially, however. First, we increase the number of regions to three, all of them linked by trade and asset flows plus, for the EMU countries, a common monetary policy. Second, we include involuntary unemployment along the lines of Galí (2010) and Galí et al. (2011). Third, we introduce an extensive fiscal block that interacts in various ways with the real economy along the lines of Stähler and Thomas (2012). To be precise, fiscal authorities can use taxes on consumption, labor income, returns on physical capital holdings as well as lump-sum taxes to generate revenue. Of course, they can also issue debt. Expenditures include interest payments on outstanding debt, public purchases, public investment, transfers and payments for public employees as well as unemployment benefits. The public capital stock as well as public employees are assumed to have a positive impact on private sector productivity as in Pappa (2009). Last, we include two more transmission channels helping the model to reproduce realistic impulses to public spending and public transfer shocks: private utility-enhancing government spending along the lines of Leeper et al. (2009) and so-called “rule-of-thumb” households à la Galí et al. (2007) who do not have access to capital markets and spend their entire income on consumption each period.¹

To estimate the model we construct a large innovative data set for Germany, the rest of EMU (an aggregate of the countries Austria, Belgium, Finland, France, Italy, the Netherlands, Portugal and Spain) and the rest of the world (an aggregate of Brazil, Canada, China, India, Japan, Russia, the United Kingdom, and the United States). The innovation comes in, first, by splitting Euro Area data into two blocks to estimate the interactions between them and, second, by constructing a rich set of quarterly fiscal

¹The empirical literature based on vector-autoregressive (VAR) models has shown that a (persistent) increase in government spending leads to a positive reaction of private consumption (see, among others, Blanchard and Perotti, 2002, Fatás and Mihov, 2001). The standard real business cycle or New Keynesian model does not recover this finding, which has become known as the “consumption puzzle” in the literature. To reconcile these findings, Galí et al. (2007) were the first to include the above mentioned “rule-of-thumb” households into such models.

variables (18 of 39 time series are fiscal). The model is being used for policy simulations in the Working Group on Econometric Modelling (WGEM) of the European System of Central Banks (ESCB) and the Deutsche Bundesbank

We find that, not surprisingly, stimulus programmes positively affected the domestic GDP growth rates while consolidation measures had a negative impact. The contribution of fiscal policy on domestic GDP growth was only small, however, amounting to a maximum of 1.6% for Germany and 0.8% for the rest of the Euro Area in terms of annualized quarter-on quarter growth rates. The main driver for the evolution of GDP were rest of the world and risk premia shocks, followed by domestic non-fiscal shocks, amongst them the technology shock being the most important one. Spillovers of fiscal policy shocks are negligibly small, which holds for spillovers of shocks in Germany to the rest of the Euro Area and vice versa. This latter finding is confirmed by an impulse-response analysis and by calculating the corresponding multipliers. Hence, relating these findings to current discussions, our analysis suggests that domestic fiscal policy has little effects on the other regions' GDP within EMU and can, therefore, contribute only little to solving the imbalances problem.

Fiscal policy analysis within DSGE models has gained momentum recently. Therefore, our analysis fits into the literature quite nicely. The relatively large disaggregation in fiscal policy instruments as well as the multi-region structure allows us to analyze the domestic impact of fiscal policy and its spillovers more detailed relative to what has been done in the literature so far. Without completeness, relevant studies analyzing fiscal policy in DSGE models include Galí and Monacelli (2008), who analyze optimal fiscal and monetary policy in a currency union. ... MORE ... The study most closely related to ours is by Coenen et al. (2013). They use the European Central Bank's New Area-Wide Model (NAWM; see Christoffel et al., 2008) to quantify the impact of fiscal policy on the euro area growth rate during the crisis and find ... MORE ... Our model supplements their analysis as we are able to disentangle the effects of country-specific fiscal policy and the corresponding spillovers. Furthermore, we have a richer fiscal environment and richer feedback of fiscal policy on the real through several channels.

The rest of the paper is organized as follows. Section 2 describes the model. In section 3, we present the estimation, while we conduct the quantitative exercises in section 4. Section 5 concludes.

2. The model

In this section, we will provide an overview of *GEAR* describing preferences, technologies and the behavior of economic agents. Most derivations and first-order conditions are relegated to the appendix due to space constraints and readability; a detailed equation summary is available upon request.

From a bird's eye perspective, *GEAR* consists of three regions: Germany, the Euro Area (without Germany) and the Rest of the world. Each region is inhabited by four types of agents: households, firms, a fiscal and a monetary authority. Within the euro area, there is only one common monetary authority.

Households make optimal choices regarding savings in physical capital as well as national and international assets and purchases of consumption and investment goods. The latter add to the private-sector capital stock which is rented out to private firms. Household members also decide whether or not to participate in the labor market. Those who participate may find a job in the private or in the public sector or stay unemployed. Hence, households receive interest and wage payments, unemployment benefits and other fiscal transfers, and they pay taxes. In line with Galí et al. (2007), we also assume that a fraction of households does not participate in asset markets and consumes the entire income each period. Those households have become known as “rule-of-thumb” (RoT) households in the literature; we call the other type of household “optimizers”.

On the production side, monopolistic competitors in each region produce a variety of differentiated products and sell these to the home and foreign market. We assume that there is no price discrimination between markets. Firms use labor and private capital as production inputs. Public services and the public capital stock can be productivity-enhancing. However, the provision of these inputs is outside the control of firms and conducted by the fiscal authority. Cost minimization determines the amount of labor and capital input demanded by each firm. Because firms enjoy monopolistic power, they are able to set their nominal price. Price setting is undertaken by a union. For both, wage and price setting, we assume the existence of Rotemberg adjustment costs (see Ascari et al., 2011, and Ascari and Rossi, 2011, for a discussion).

The fiscal authority purchases consumption and investment goods produced in the private sector. The former is private utility-enhancing, while the latter increases the public capital stock which may, in turn, improve private-sector productivity (for example, because of better infrastructure). The government also employs public-sector workers for whom it has to pay wages. Services provided by these public-sector workers may also affect private-sector productivity positively (for example, because of better governance). Introducing immediate positive spillovers from the public to the private sector follows the idea of Pappa (2009) or Leeper et al. (2009, 2010). Furthermore, the fiscal authority pays unemployment benefits and other transfers to private households. It also has to pay interest on outstanding debt. Fiscal authorities finance themselves with distortionary taxes on private consumption, on labor income and on capital returns as well as social security contributions paid by firms. They can also issue new debt. The monetary authority sets the nominal reference interest rates. In the euro area, it sets a common rate according to a Taylor-type rule that responds to measured area-wide inflation and output gap. In this paper, we use a version of the model in which the rest of the world is reduced to a three-equation VAR process (output, inflation and interest rate) because modeling the third region in detail does not add very much to the current analysis, while it keeps estimation more tractable as in Christiano et al. (2011). However, a version of the model with the third region fully modeled exists.

Figure 1 graphically illustrates the working and the flows of our model. In what follows, we will index each region by $i = a, b, c$. Regions are assumed to be identical in terms of their economic structure, but they differ in terms of size and parameter values.

Without loss of generality, we index country- a agents in the interval $[0, 1]$, country- b agents in $[0, \mathcal{P}^b]$ and country- c agents in $[0, \mathcal{P}^c]$. Hence, \mathcal{P}^j , with $j = b, c$, is the size of country j relative to country a .²

Figure 1 about here

2.1. Firms and production

We will continue by presenting the necessary equations for country a . Those for the other regions are analogous and can be found in the equation summary. We assume that, in each country, there is a measure- \mathcal{P}^i (equal to one for country a) continuum of firms in the final goods sector. Firms are owned by optimizing households. Each final goods producer purchases a variety of differentiated intermediate goods, bundles these and sells them to the final consumer under perfect competition.³ The producer price index (PPI) of a goods produced in country i and sold in j is defined as $P_t^{i,j}$. We assume that the law of one price holds across regions, so firms in country a set their price $P_t^{a,a}$ for all markets. Multiplying with the nominal exchange rate, then, yields the price of country- a goods charged in the other countries, ie $P_t^{b,a} = S_t^{b,a} P_t^{a,a}$ and $P_t^{c,a} = S_t^{c,a} P_t^{a,a}$, where the nominal exchange rate $S_t^{j,a}$ is defined as country j currency per unit of country a currency. It is one in the monetary union. The maximization problem of the representative final goods firm reads

$$\max_{\{\tilde{y}_t^a(z): z \in [0,1]\}} P_t^{a,a} Y_t^a - \int_0^1 P_t^{a,a}(z) \tilde{y}_t^a(z) dz, \quad (1)$$

where $Y_t^a = \left(\int_0^1 \tilde{y}_t^a(z)^{(\theta_a-1)/\theta_a} dz \right)^{\theta_a/(\theta_a-1)}$ is the production function of the producer of final goods, $\tilde{y}_t^a(z)$ his demand for each differentiated input good z and $P_t^{a,a}(z)$ the price of each input. The first-order condition of this problem yields $\tilde{y}_t^a(z) = (P_t^{a,a}(z)/P_t^{a,a})^{-\theta_a} Y_t^a$, which implies that PPI of country a is given by $P_t^{a,a} = \left(\int_0^1 P_t^{a,a}(z)^{1-\theta_a} dz \right)^{1/(1-\theta_a)}$.

Private intermediate goods firms on the continuum z operate as monopolistic competitors in the product market. Each firm produces its intermediate good variety with

²Our framework is, therefore, quite flexible to be applied to other countries, too. For example, $1 + \mathcal{P}^b + \mathcal{P}^c$ is the world's relative size to country a , when $\mathcal{P}^b, \mathcal{P}^c \rightarrow \infty$, country a can be considered any small open economy, and so on. In our estimation, country a will be Germany, region b the rest of EMU, which is an aggregate of Austria, Belgium, Finland, France, Italy, the Netherlands, Portugal and Spain, while region c is the rest of the world, being an aggregate of Canada, the USA and UK, China, India, Japan, Russia and Brazil.

³An alternative would be a final consumer who takes care of the bundling as in, among others, Forni et al. (2009). The allocation, however, is the same.

the following Cobb-Douglas production function

$$y_t^a(z) = e^{\epsilon_t^{A_a}} \left(\zeta_a \left(K_t^{G,a} \right)^{\eta^{K^G,a}} \left(N_t^{G,a} \right)^{\eta^{N^G,a}} \right) \left[u_t^a K_{t-1}^a(z) \right]^{\alpha_a} \left[N_t^{P,a}(z) \right]^{1-\alpha_a} - \Omega_a, \quad (2)$$

where $\epsilon_t^{A_a}$ is an AR(1) productivity shock process, identical across firms, and Ω_a is a fixed cost yielding steady-state profits to be zero. The parameter $0 < \alpha_a < 1$ gives the share of private capital, K_t^a , in production. u_t^a is the capital utilization rate and $N_t^{P,a}$ denotes private-sector employment.

Many DSGE models ignore that government actions directly affect the private sector. However, it is very likely – and probably nobody would abandon this idea entirely – that the public capital stock, $K_t^{G,a}$, and at least the majority of public employees, $N_t^{G,a}$, have a positive effect on private-sector productivity due to, for example, better infrastructure, efficient governance, education and so on. As we are not able to capture all possible channels through which the government could affect private-sector productivity in a tractable way, we apply the short cut of Leeper et al. (2009, 2010) and Pappa (2010). They assume that public investment and public employment, provided by the government, affects private-sector productivity as stated in equation (2). Here, $\zeta_a > 0$ is a scaling parameter, $\eta^{K^G,a} \geq 0$ determines the relevance of public capital in the private-sector productivity function, while $\eta^{N^G,a} \geq 0$ the relevance of public employment (for $\eta^{K^G,a} = \eta^{N^G,a} = 0$, there is no effect). We will describe in the fiscal authority-section below how $K_t^{G,a}$ and $N_t^{G,a}$ are determined; they are both outside the firms' influence.

With $r_{k,t}^a$ being the consumer price index (CPI)-deflated rental rate of capital and $(1 + \tau_t^{sc,a}) w_t^a$ being gross labor costs, including CPI-deflated private-sector wages, w_t^a , plus social security contributions at rate $\tau_t^{sc,a}$, firm z 's cost minimization problem yields the following capital-to-labor ratio

$$\frac{r_{k,t}^a}{w_t^a (1 + \tau_t^{sc,a})} = \frac{N_t^{P,a}(z)}{u_t^a K_{t-1}^a(z)} \cdot \frac{\alpha_a}{1 - \alpha_a}, \quad (3)$$

which is common to all firms. Real CPI-deflated marginal costs (then, also common across firms) are hence given by

$$mc_t^a = \frac{\left(r_{k,t}^a \right)^{\alpha_a} \left(w_t^a (1 + \tau_t^{sc,a}) \right)^{1-\alpha_a}}{e^{\epsilon_t^{A_a}} \left(\zeta_a \left(K_t^{G,a} \right)^{\eta^{K^G,a}} \left(N_t^{G,a} \right)^{\eta^{N^G,a}} \right) \alpha_a^{\alpha_a} (1 - \alpha_a)^{1-\alpha_a}}. \quad (4)$$

We will derive the CPI in more detail in the next section. Each intermediate goods producer sets its own price $P_t^{a,a}(z)$ to maximize intertemporal profits: the difference between revenues and production as well as Rotemberg price adjustment costs, the latter

indicated by a cost parameter γ_a . The maximization problem in CPI-terms can be stated as

$$\begin{aligned} \max_{\{P_t^{a,a}(z): z \in [0,1]\}} \quad & E_t \sum_{s=0}^{\infty} \beta_a^s \frac{\lambda_{o,t+s}^a}{\lambda_{o,t}^a} \left[\left(\frac{P_{t+s}^{a,a}(z)}{P_{t+s}^a} - mc_{t+s}^a \right) y_{t+s}^a(z) \right. \\ & \left. - \frac{\gamma_a}{2} \left(\frac{P_{t+s}^{a,a}(z)}{(\pi_{w,t+s-1}^{a,a})^{\xi_a} (\bar{\pi}^{a,a})^{1-\xi_a} P_{t+s-1}^{a,a}(z)} - 1 \right)^2 \frac{P_{t+s}^{a,a}}{P_{t+s}^a} Y_{t+s}^a \right], \end{aligned} \quad (5)$$

subject to $y_{t+s}^a(z) = \tilde{y}_{t+s}^a(z)$ given above. The parameters $\xi_{a,1}, \xi_{a,2} \geq 0$ indicate potential price indexation on past inflation, $\pi_{w,t-1}^a$, and steady-state inflation, $\bar{\pi}^a$, respectively (see Ascari et al. 2011). Note that the intertemporal discount factor of a firm includes the marginal utility of optimizing households, $\lambda_{o,t}^a$, determined below, because optimizers own firms.

2.2. Households, consumption and savings

Following Galí et al. (2007), we assume that each region is populated by two types of representative households: optimizing and non-Ricardian “rule-of-thumb” (RoT) households, indexed by $x = o, r$ for optimizers and RoTs, respectively. They differ in that RoTs do not save and borrow but consume all their labor income each period. Of total population, RoT households make up a share $\mu^a \in [0, 1]$, while the remaining share $(1 - \mu^a)$ behaves in a Ricardian way. As in Galí et al. (2011), household members are represented by the unit square and indexed by a pair $(h_x, j_x) \in [0, 1] \times [0, 1]$. Household members differ in the type of labor service they are specialized in, represented by the dimension $h_x \in [0, 1]$, and by their personal disutility of work, represented by the dimension $j_x \in [0, 1]$. The latter is given by $\kappa_a^w \cdot e^{\epsilon_t^{N_a}} \cdot j_x^{\varphi_a}$ if employed and zero otherwise. $\kappa_a^w > 0$ is an exogenous labor disutility scaling parameter and $\epsilon_t^{N_a}$ an AR(1) labor disutility shock process. $\varphi_a > 0$ determines the shape of the distribution of work disutilities across individual household members. Values not indexed by x are common across household types. Assuming that household members’ utility positively depends on consumption and that there is full risk sharing of consumption among household members, as in Merz (1995) or Andolfatto (1996), household-type x ’s utility can be writ-

ten as

$$\begin{aligned}
& E_t \sum_{s=0}^{\infty} \beta_a^s U(\tilde{C}_{x,t+s}^a, N_{x,t+s}^a(h_x)) \\
&= E_t \sum_{s=0}^{\infty} \beta_a^s e^{\epsilon_{t+s}^{\beta_a}} \left[\frac{\left(\tilde{C}_{x,t+s}^a - h_a \tilde{C}_{x,t+s-1}^a \right)^{1-\sigma_a} - 1}{1-\sigma_a} - \kappa_a^w e^{\epsilon_{t+s}^{N_a}} \int_0^1 \int_0^{N_{x,t+s}^a(h_x)} j_x^{\varphi_a} dj dh_x \right] \quad (6) \\
&= E_t \sum_{s=0}^{\infty} \beta_a^s e^{\epsilon_{t+s}^{\beta_a}} \left[\frac{\left(\tilde{C}_{x,t+s}^a - h_a \tilde{C}_{x,t+s-1}^a \right)^{1-\sigma_a} - 1}{1-\sigma_a} - \kappa_a^w e^{\epsilon_{t+s}^{N_a}} \int_0^1 \frac{N_{x,t+s}^a(h_x)^{1+\varphi_a}}{1+\varphi_a} dh_x \right],
\end{aligned}$$

where $0 < \beta_a < 1$ is a subjective discount factor, $\epsilon_t^{\beta_a}$ an AR(1) preference shock process, and h_a an external habit persistence parameter. σ_a governs the elasticity of intertemporal substitution. $N_{x,t}^a(h_x) \in [0, 1]$ denotes the household type x -specific employment rate in period t among workers specialized in type h_x labor.

$$\tilde{C}_{x,t}^a = \left[(\alpha_G^a)^{\frac{1}{\nu_G^a}} (C_{x,t}^a)^{\frac{\nu_G^a-1}{\nu_G^a}} + (1 - \alpha_G^a)^{\frac{1}{\nu_G^a}} (C_t^{G,a})^{\frac{\nu_G^a-1}{\nu_G^a}} \right]^{\frac{\nu_G^a}{\nu_G^a-1}}$$

is effective consumption, which is assumed to be a constant-elasticity-of-substitution index of private consumption, $C_{x,t}^a$, and government purchases, $C_t^{G,a}$, as in Leeper et al. (2009). When $\alpha_G^a = 1$, effective consumption collapses to private consumption. We are, then, back to a model in which government purchases are pure waste. ν_G^a is the elasticity of substitution between private and government consumption.⁴ Consumption of private goods, $C_{x,t}^a$, is a composite of goods produced at home and abroad. In country a , household type- x consumption aggregator is given by

$$C_{x,t}^a = \left[(n_a^a)^{\frac{1}{\eta_a}} (C_{x,t}^{a,a})^{\frac{\eta_a-1}{\eta_a}} + (n_b^a)^{\frac{1}{\eta_a}} (C_{x,t}^{a,b})^{\frac{\eta_a-1}{\eta_a}} + (n_c^a)^{\frac{1}{\eta_a}} (C_{x,t}^{a,c})^{\frac{\eta_a-1}{\eta_a}} \right]^{\frac{\eta_a}{\eta_a-1}},$$

where n_i^a , with $i = a, b, c$, are the weights of goods in the consumption bundle according to their origin, implying $n_a^a + n_b^a + n_c^a = 1$, and η_a is the elasticity of substitution between these goods. $C_{x,t}^{i,j}$, with $i, j = a, b, c$, is a good consumed by households of type x in region i which is produced in region j . The weights n_i^a depend on relative country size \mathcal{P}^i and

⁴ $\nu_G^a \rightarrow 0$ indicates that private and public consumption are perfect complements, $\nu_G^a \rightarrow \infty$ implies that the two are perfect substitutes and $\nu_G^a \rightarrow 1$ yields the Cobb-Douglas case.

an index of trade openness between country i and j , ϑ_j^i . For country a , we get

$$n_a^a = 1 - \frac{\vartheta_c^a \mathcal{P}^c + \vartheta_b^a \mathcal{P}^b}{1 + \mathcal{P}^b + \mathcal{P}^c}, \quad n_b^a = \frac{\vartheta_b^a \mathcal{P}^b}{1 + \mathcal{P}^b + \mathcal{P}^c}, \quad n_c^a = \frac{\vartheta_c^a \mathcal{P}^c}{1 + \mathcal{P}^b + \mathcal{P}^c}.$$

We assume that it holds that $\vartheta_j^i = \vartheta_i^j$ for all $i, j = a, b, c$. For $\vartheta_j^i < 1$, there exists home bias in consumption such that households prefer the domestically produced good. We also assume perfectly analogous aggregators for the demand of private investment goods, labeled $I_{o,t}^a$ and $I_{o,t}^{i,j}$ (remember that only optimizing households invest in private capital as RoTs consume all their labor income each period).

To derive the CPI of country a , we note that total spending on consumption goods must obey $P_t^a C_{x,t}^a = P_t^{a,a} C_{x,t}^{a,a} + P_t^{a,b} C_{x,t}^{a,b} + P_t^{a,c} C_{x,t}^{a,c}$, where $P_t^{i,j}$ is the PPI described in the previous section. From this relation, we can derive domestic CPI, which is hence given by P_t^a .

Nominal consumption expenditures of RoT households amount to $(1 + \tau_t^{C,a}) P_t^a C_{r,t}^a$, where P_t^a is the *consumer price index* (CPI) in country a , $C_{r,t}^a$ the real level of consumption as described above and $\tau_t^{C,a}$ the consumption tax rate. Income of RoTs is given by net wage income from employment in the private and the public sector, $N_t^{P,a}$ and $N_t^{G,a}$, paying nominal gross wages W_t^a and $W_t^{G,a}$. The labor tax rate is $\tau_t^{w,a}$. Note that neither employment nor wages are indexed by x as we assume that wage bargaining and employment distribution are undertaken by a union and the government, who both distribute labor and wages uniformly across household types (explained in more detail in the next section). Unemployed household members receive nominal unemployment benefits $P_t^a UB^a$. Unemployed are those members who decided to participate in the labor market, $L_{r,t}^a$, derived in the next section, but who did not find a job, $U_{r,t}^a = L_{r,t}^a - N_t^a$. Here, it is important to note that, while employment rates and wages are independent of the household type, the number of household members participating in the labor market can differ across types. Furthermore, households receive a type-specific lump-sum transfer $P_t^a TR_{r,t}^a$. Summarizing and noting that RoTs spend their entire income each period, their budget constraint becomes

$$(1 + \tau_t^{C,a}) P_t^a C_{r,t}^a = (1 - \tau_t^{w,a}) (W_t^a N_t^{P,a} + W_t^{G,a} N_t^{G,a}) + P_t^a UB^a (L_{r,t}^a - N_t^a) + P_t^a TR_{r,t}^a. \quad (7)$$

When dividing equation (7) by P_t^a , we get the budget constraint in real CPI-terms, where we then define $w_t^a = W_t^a / P_t^a$ and $w_t^{G,a} = W_t^{G,a} / P_t^a$ as real wages. Analogously, the

budget constraint for optimizing households – already in real terms – is given by

$$\begin{aligned}
& \left(1 + \tau_t^{C,a}\right) C_{o,t}^a + I_{o,t}^a + B_{o,t}^{a,a} + \sum_{j=b,c} S_t^{a,j} B_{o,t}^{a,j} + B_{o,t}^{G,a} = (1 - \tau_t^{w,a}) \left(w_t^a N_t^{P,a} + w_t^{G,a} N_t^{G,a}\right) \\
& + UB^a (L_{o,t}^a - N_t^a) + TR_{o,t}^a + \frac{(1 + i_{t-1}^a) e^{\epsilon_t^{RP,EA}}}{\pi_t^a} B_{o,t-1}^{a,a} + \frac{(1 + i_{t-1}^{a,b}) e^{\epsilon_t^{RP,EA}}}{\pi_t^a} B_{o,t-1}^{a,b} \\
& + S_t^{a,c} \frac{(1 + i_{t-1}^{a,RoW}) e^{\epsilon_t^{RP,RoW}}}{\pi_t^a} B_{o,t-1}^{a,RoW} \frac{(1 + i_{t-1}^{G,a})}{\pi_t^a} B_{o,t-1}^{G,a} + (1 - \tau_t^{k,a}) [r_{k,t}^a u_t^a - \Gamma(u_t^a)] k_{o,t-1}^a \\
& + \tau_t^{k,a} \delta_a k_{o,t-1}^a + D_{o,t}^a - T_{o,t}^a, \tag{8}
\end{aligned}$$

where we have to take into account that optimizers save and borrow. $B_{x,t}^{i,j}$ are private bonds purchased in country i issued by country j , $B_t^{G,a}$ is a government bond issued by the fiscal authority in country a , which is held by domestic households, and $I_{o,t}^a$ are purchases of investment goods, which is, as already stated, an analogous aggregator as private consumption. $S_t^{a,j}$ are nominal exchange rates between region a and j (for the euro area, it is equal to one). In addition to the wage and transfer income of RoTs, optimizers also receive interest on their bond holdings, at rates $i_t^{a,j}$ for private and $i_t^{G,a}$ for government bonds, respectively. Furthermore, only optimizers pay lump-sum taxes $T_{o,t}^a$. $\pi_t^a = P_t^a / P_{t-1}^a$ is CPI inflation from period $t-1$ to period t . They also receive a return $r_{k,t}^a$ on their capital $k_{o,t}^a$ when it is utilized at rate $u_{k,t}^a$. Capital utilization is costly, with a cost function $\Gamma(u_t^a) = (1/\psi_a^k) r_{k,t}^a (e^{\psi_a^k (u_t^a - 1)} - 1)$. Furthermore, capital depreciates at rate δ_a . The government taxes capital gains net of utilization costs at rate $\tau_t^{k,a}$, while capital depreciation is assumed to be tax exempt. $D_{o,t}^a$ are firms' profits. $e^{\epsilon_t^{RP,EA}}$ and $e^{\epsilon_t^{RP,RoW}}$ are exogenous “risk premium” shock processes for the Euro Area as a whole and from the rest of the world similar to Christoffel et al. (2008) or Coenen et al. (2013). The capital law-of-motion is given by

$$k_{o,t}^a = (1 - \delta_a) k_{o,t-1}^a + \left(I_{o,t}^a - I_{o,t}^a \frac{\psi_a^i}{2} \left(\frac{I_{o,t}^a}{I_{o,t-1}^a} - 1 \right)^2 \right) e^{\epsilon_t^{I,a}} \tag{9}$$

which states that today's capital stock equals yesterday's capital stock net of depreciation plus new investments net of investment adjustment costs, $\psi_a^i / 2 \left(I_{o,t}^a / I_{o,t-1}^a - 1 \right)^2$. The parameters ψ_a^k and ψ_a^i determine how high capital utilization and investment adjustment cost are, respectively. $\epsilon_t^{I,a}$ is an exogenous AR(1) investment technology shock process. Including investment adjustment costs has become standard in estimated DSGE models, see Christiano et al. (2005, 2011) for a discussion.

By maximizing equation (6) subject to (8) and (9), we can now derive the optimizers'

Euler equations for private and public bond holdings, physical capital investments and their marginal utility of consumption. We can derive the latter for RoT households by using equations (6) and (7). We relegate all this to the appendix. Note further that any household-type specific variable X_t^x can be aggregated as $X_t = (1 - \mu^a) X_t^o + \mu^a X_t^r$ when concerned with both household types, and as $X_t = (1 - \mu^a) X_t^o$ when exclusively concerned with optimizing households.

2.3. Labor supply, labor demand and wage setting

Turning to labor demand, we have to differentiate between private and public sector demand. As in Forni et al. (2009), we assume that labor demand (in the private and the public sector) gets uniformly allocated among household types (ie optimizer and RoT, respectively) and that public sector labor demand, $N_t^{G,a}$, is an autoregressive exogenous stochastic process described in the next section. We assume that public-sector wages include a markup, mg_t^a , on private sector wages consistent with OECD data. In particular, we assume that

$$W_t^{G,a} = (1 + mg_t^a) W_t^a$$

holds. In the private sector, a perfectly competitive agency buys the differentiated individual labor services supplied by households, transforms them into a homogenous composite of labor input, and sells that to intermediate goods producers. Hence, labor agencies solve

$$\max_{N_t^{P,a}(\mathbf{h}) : \mathbf{h} \in [0,1]} N_t^{P,a} = \left(\int_0^1 \left(N_t^{P,a}(\mathbf{h}) \right)^{(\theta_a^w - 1)/\theta_a^w} d\mathbf{h} \right)^{\theta_a^w / (\theta_a^w - 1)}$$

subject to $\int_0^1 W_t^a(\mathbf{h}) N_t^{P,a}(\mathbf{h}) d\mathbf{h} = \overline{WB}_t^a$, where \overline{WB}_t^a is a given level of the wage bill. The solution of this problem is the private-sector labor demand for each variety,

$$N_t^{P,a}(\mathbf{h}) = \left(\frac{W_t^a(\mathbf{h})}{W_t^a} \right)^{-\theta_a^w} N_t^{P,a}, \quad (10)$$

where total private-sector labor demand, $N_t^{P,a}$, is defined above and W_t^a is the average nominal wage paid in the private sector. It is, of course, clear that total employment is an aggregate of public and private employment, ie $N_t^a = N_t^{P,a} + N_t^{G,a}$.

In order to derive a labor market equilibrium, we will have to determine labor supply and demand as well as wage setting. Let us, first, turn to the labor supply decision of households. Taking labor market conditions (ie wages and employment) as given, any household member specialized in type \mathbf{h}_x labor will find it optimal to participate in the labor market if and only if utility from working exceeds his disutility, ie if

$$\lambda_{x,t}^a \left[(1 - \tau_t^{w,a}) \left(W_t^a N_t^{P,a} + W_t^{G,a} N_t^{G,a} \right) + P_t^a UB^a (L_{r,t}^a - N_t^a) \right] \geq N_t^a \kappa_a^w e^{\epsilon_{t+s}^{N_a}} j_x^{\varphi_a},$$

where $\lambda_{x,t}^a$ is marginal utility of consumption.⁵ When defining the marginal member for which this condition holds with equality as $L_{x,t}^a$ and noting that $j_x \in [0, 1]$, $L_{x,t}^a$ can be seen as the labor supply of household-type x ; see Galí et al. (2011) for a more detailed discussion. Hence, the households' labor supply decision can be summarized as

$$\lambda_{x,t}^a \left[(1 - \tau_t^{w,a}) \left(W_t^a N_t^{P,a} + W_t^{G,a} N_t^{G,a} \right) + P_t^a UB^a (L_{r,t}^a - N_t^a) \right] = N_t^a \kappa_a^w e^{\epsilon_{t+s}^{N_a}} (L_{x,t}^a)^{\varphi_a}. \quad (11)$$

To determine wages in the private sector, we assume that there are utilitarian unions for each labor type h_x always representing optimizing and RoT households according to their shares in population. Unions maximize income of its members by optimally choosing nominal wages $W_t^a(h)$, taking into account the disutility of work and the effects on labor supply and demand. Furthermore, wage setting is due to Rotemberg adjustment costs, indicated by a parameter γ_a^w . To be precise, each union maximizes

$$\begin{aligned} E_t \sum_{s=0}^{\infty} \beta_a^s e^{\epsilon_{t+s}^{N_a}} \left\{ \mu^a \left[\lambda_{t+s}^{r,a} \left((1 - \tau_{t+s}^{w,a}) \left(\frac{W_{t+s}^a(h)}{P_{t+s}^a} N_{t+s}^{P,a}(h) + (1 + m_{t+s}^a) \frac{W_{t+s}^a(h)}{P_{t+s}^a} N_{t+s}^{G,a}(h) \right) \right. \right. \right. \\ \left. \left. + UB^a (L_{t+s}^{r,a}(h) - N_{t+s}^a(h)) - \frac{v_a^w}{2} \left(\frac{W_{t+s}^a(h)}{(\pi_{w,t+s-1}^a)^{\bar{\zeta}_{a,1}^w} (\bar{\pi}^a)^{\bar{\zeta}_{a,2}^w} W_{t+s-1}^a(h)} - 1 \right)^2 \frac{W_{t+s}^a(h)}{P_{t+s}^a} \right) - \kappa_a^w e^{\epsilon_{t+s}^{N_a}} \frac{N_{t+s}^a(h)^{1+\varphi_a}}{1 + \varphi_a} \right] \\ \left. + (1 - \mu^a) \left[\lambda_{t+s}^{o,a} \left((1 - \tau_{t+s}^{w,a}) \left(\frac{W_{t+s}^a(h)}{P_{t+s}^a} N_{t+s}^{P,a}(h) + (1 + m_{t+s}^a) \frac{W_{t+s}^a(h)}{P_{t+s}^a} N_{t+s}^{G,a}(h) \right) \right. \right. \right. \right. \\ \left. \left. + UB^a (L_{t+s}^{o,a}(h) - N_{t+s}^a(h)) - \frac{v_a^w}{2} \left(\frac{W_{t+s}^a(h)}{(\pi_{w,t+s-1}^a)^{\bar{\zeta}_{a,1}^w} (\bar{\pi}^a)^{\bar{\zeta}_{a,2}^w} W_{t+s-1}^a(h)} - 1 \right)^2 \frac{W_{t+s}^a(h)}{P_{t+s}^a} \right) - \kappa_a^w e^{\epsilon_{t+s}^{N_a}} \frac{N_{t+s}^a(h)^{1+\varphi_a}}{1 + \varphi_a} \right] \right\}, \end{aligned}$$

with respect to $\{W_{t+s}^a(h), N_{t+s}^{P,a}(h), L_{t+s}^{r,a}(h), L_{t+s}^{o,a}(h) : h \in [0, 1]\}$ subject to (11) for each household type x , (10) and $N_t^a = N_t^{P,a} + N_t^{G,a}$. The solution is symmetric, so that $W_t^a(h) = W_t^a$, $L_t^{o,a}(h) = L_t^{o,a}$, $L_t^{r,a}(h) = L_t^{r,a}$ and $N_t^{P,a}(h) = N_t^{P,a}$ for all h in equilibrium. Defining $L_t^a = (1 - \mu^a) L_t^{o,a} + \mu^a L_t^{r,a}$ as the total labor force, we can then define the unemployment rate as $u_t^a = (L_t^a - N_t^a) / L_t^a$. As for price setting, we allow for potential indexation on past wage inflation, $\pi_{w,t-1}^a$, and steady-state price inflation, indicated by the parameters $\bar{\zeta}_{a,1}^w, \bar{\zeta}_{a,2}^w \geq 0$. The first-order conditions of this problem then determine wages in the private sector. They are relegated to the appendix.

2.4. Fiscal authority

The real (CPI-deflated) per capita value of end-of-period government debt, $B_t^{G,a} = (1 - \mu^a) B_{o,t}^{G,a}$, evolves according to a standard debt accumulation equation,

$$B_t^{G,a} = \frac{(1 + i_{t-1}^{G,a})}{\pi_t^a} B_{t-1}^{G,a} + PD_t^a, \quad (12)$$

⁵Multiplying real variables – here, the household income from participating in the labor market – with marginal utility allows us to “translate” these real variables into utility terms, which then can be compared to the disutility term.

where $PD_t^a = G_t^a - Rev_t^a$ denotes the real per capita primary deficit, being defined as total primary expenditures (excluding interest payments on outstanding debt),

$$G_t^a = R_t^{a,a} \left(C_t^{G,a} + I_t^{G,a} \right) + UB^a \left(\mu^a (L_t^{r,a} - N_t^a) + (1 - \mu^a) (L_t^{o,a} - N_t^a) \right) \\ + (1 + \tau_t^{sc,a}) N_t^{G,a} w_t^{G,a} + TR_t^a$$

minus primary revenues,

$$Rev_t^a = (\tau_t^{w,a} + \tau_t^{sc,a}) \left(w_t^a N_t^{P,a} + w_t^{G,a} N_t^{G,a} \right) + \tau_t^{k,a} \left(r_t^{k,a} u_t^a - \Gamma_t^a(u_t^a) - \delta_a \right) K_{t-1}^a \\ + \tau_t^{c,a} C_t^a + T_{o,t}^a.$$

We assume full home bias in government consumption and investment, $C_t^{G,a}$ and $I_t^{G,a}$, which can be justified by the fact that there is evidence for a strong home bias in government procurement (see, among others, Trionfetti, 2004, and Brulhart and Trionfetti, 2004). $R_t^{a,a} = P_t^{a,a} / P_t^a$ is the relative price between home-country PPI and home-country CPI (an analogous definition holds for $R^{i,j}$). Given public investment, the public sector capital stock evolves according to $K_t^{G,a} = (1 - \delta_a^G) K_{t-1}^{G,a} + I_t^{G,a}$. We abstract from capital adjustment costs here, because, as we will see below, public investment is assumed to be a given exogenous stochastic process. Including capital adjustment costs would only add to the expenditure side. Finally, transfers are distributed among the two types of households as in Coenen et al. (2013). Precisely, this implies that they are distributed according to

$$\bar{\mu}^a \left(\frac{TR_{o,t}^a}{\bar{TR}_o^a} - 1 \right) = (1 - \bar{\mu}^a) \left(\frac{TR_{r,t}^a}{\bar{TR}_r^a} - 1 \right).$$

We assume that, for each fiscal instrument on the expenditure side $X^a \in \{C^{G,a}, I^{G,a}, N^{G,a}, TR_o^a, TR_r^a\}$, which the government has available, the following rule applies

$$\log \left(\frac{X_t^a}{\bar{X}^a} \right) = \rho^{X,a} \log \left(\frac{X_{t-1}^a}{\bar{X}^a} \right) - \zeta^{X,B^{G,a,a}} \log \left(\frac{B_{t-1}^{G,a}}{\bar{B}^{G,a}} \right) + \zeta^{X,y,a} \log \left(\frac{Y_{t-1}^a}{\bar{Y}^a} \right) + v_t^{X,a}. \quad (13)$$

For each instrument on the revenue side $X^a \in \{\tau^{w,a}, \tau^{sc,a}, \tau^{k,a}, \tau^{c,a}, T_{o,t}^a\}$, which the government has available, the following rule applies⁶

$$X_t^a - \bar{X}^a = \rho^{X,a} X_{t-1}^a - \bar{X}^a + \zeta^{X,B^{G,a,a}} \log \left(\frac{B_{t-1}^{G,a}}{\bar{B}^{G,a}} \right) + \zeta^{X,y,a} \log \left(\frac{Y_{t-1}^a}{\bar{Y}^a} \right) + v_t^{X,a}. \quad (14)$$

⁶Note that in the case of lump-sum taxes, we consider the deviation from steady state over steady state output, $\frac{T_{o,t}^a - \bar{T}_o^a}{\bar{Y}^a}$, to avoid potential problems with the sign of steady-state lump-sum taxes.

$\nu_t^{X,a}$ is an iid (discretionary) fiscal policy shock with mean zero and variance $\sigma^{X,a}$, $\rho^{X,a}$ is a persistence parameter and $\zeta^{X,B^{G,a},a}$ measures the responsiveness of the corresponding instrument to deviations in the debt ratio from its long-run target. In order to guarantee stability in the debt ratio, for *at least* one instrument the coefficient $\zeta^{X,B^{G,a},a}$ must be positive (see, among others, Schmitt-Grohé and Uribe, 2007, and Kirsanova and Wren-Lewis, 2012, for a discussion). $\zeta^{X,y,a}$ can be interpreted as an ad-hoc automatic stabilizing component as in Coenen et al. (2013).

2.5. Monetary authority

We assume that, in the monetary union, there is only one central bank determining the monetary policy rate i_t^{EA} . Following Stähler and Thomas (2012), it responds to deviations of area-wide CPI inflation, which is a population-share weighted average of inflation in country a and region b , from its long-run target, and to area-wide GDP growth, according to a simple Taylor-type rule (see Taylor, 1993),

$$\begin{aligned} \log \left(\frac{1 + i_t^{EA}}{1 + \bar{i}^{EA}} \right) &= \rho_i^a \log \left(\frac{1 + i_{t-1}^{EA}}{1 + \bar{i}^{EA}} \right) + (1 - \rho_i^a) \phi_\pi^{EA} \left(s \log \left(\frac{\pi_t^a}{\bar{\pi}^a} \right) + (1 - s) \log \left(\frac{\pi_t^b}{\bar{\pi}^b} \right) \right) \\ &\quad + (1 - \rho_i^a) \phi_y^{EA} \left(s \log \left(\frac{Y_t^a}{Y_{t-1}^a} \right) + (1 - s) \log \left(\frac{Y_t^b}{Y_{t-1}^b} \right) \right) + \nu_t^{M^{EA}} \end{aligned} \quad (15)$$

where $s = \frac{\mathcal{P}^a}{\mathcal{P}^a + \mathcal{P}^b}$ is the relative population-weight of country a in the monetary union, ρ_i^a is a smoothing parameter, ϕ_π^{EA} and ϕ_y^{EA} are the monetary policy's stance on inflation and output growth, respectively, and $\nu_t^{M^{EA}}$ denotes a monetary policy shock.

While there is only one policy rate in the monetary union, namely i_t^{EA} , there are two interest rates governing private savings and, thus, foreign asset holding decisions in each country, namely i_t^a and i_t^b . This could render foreign asset positions to be non-stationary. A common way to guarantee stationarity of foreign asset trade in open-economy DSGE models is the introduction of a risk premium that depends on the relative net foreign asset position of each country (see, among others, Schmitt-Grohé and Uribe, 2003). We will discuss the precise modeling of the risk premium in the international linkages section. However, different risk premia can imply interest rates i_t^a and i_t^b to be different – depending on the net foreign asset position of each country, the interest rate prevailing in the corresponding country may be above or below the policy rate. The

relation between policy rates and the prevailing interest rate is, then, given by⁷

$$\log \left(\frac{1 + i_t^{EA}}{1 + \bar{i}^{EA}} \right) = s \log \left(\frac{1 + i_t^a}{1 + \bar{i}^a} \right) + (1 - s) \log \left(\frac{1 + i_t^b}{1 + \bar{i}^b} \right). \quad (16)$$

2.6. International linkages and market clearing

Having described the structure of the national countries, it remains to determine the international linkages, i.e. trade in goods and services and assets, and market clearing. In doing so, we will first describe the trading structure of international bonds and risk premia, second, market clearing in the goods sector and the current account, and, last, the third-country VAR.

2.6.1. International bond structure and risk premia

In order to simplify (and downsize) the trading structure of privately traded bonds, and in order to avoid having to take a stance on the detailed portfolio choice of agents, we assume that residents in country a can sell bonds to region b , but not the opposite. At first sight, it appears that a can only borrow from b . However, when allowing b -region residents to sell a -bonds short, which we do, b can effectively borrow from a . By the same logic, we allow bond trade of region c with country a or region b only to take place via bonds issued by region c .

To determine interest rates paid to or charged from investors abroad, we assume that the interest rate region- b residents have to pay to country- a residents depends on the net debt position of b vis-à-vis a . The higher region b 's indebtedness with country a , the higher is the interest rate containing a risk premium relative to what country- a residents themselves would have to pay for that bond (see, among others, Schmitt-Grohé and Uribe, 2003, for a discussion of risk premia). This logic applies to all regions $i = a, b, c$ trading bonds with region $j = a, b, c$ and can, for $i \neq j$ formally be summarized by

$$1 + i_t^{i,j} = \left(1 + i_t^j \right) \left[1 - \phi \left(\exp \left(\frac{rer_t^{i,j} B_t^{i,j}}{R_t^{i,i} Y_t^i} - \frac{\bar{B}^{i,j}}{\bar{R}^{i,i} \bar{Y}^i} \right) - 1 \right) \right], \quad (17)$$

where $R_t^{i,i} = P_t^{i,i} / P_t^i$ and $rer_t^{i,j}$ is the real exchange rate between region i and j , determined in detail in the next subsection. Hence, if the term in brackets is negative, coun-

⁷Stähler and Thomas (2012) define risk premia relative to the policy rate, rather than between regions. In their specification, the central bank provides liquidity cheaper to countries who are net creditors (more expensive for debtors). Our formulation allows for the interpretation of lending rate differentials for private households and firms due to, for example, different long-term financing conditions in the Euro Area even though all union members have access to uniform short-run refinancing conditions in principle. Of course, this interpretation simply tries to justify the ad-hoc implementation of risk premia to guarantee stationarity. For an analysis explicitly dealing with this aspect, financial intermediation should be modeled in detail. For the analysis in this paper, modeling of the source of risk premia in detail is not so important.

try i 's indebtedness vis-à-vis country j increases above the “normal” steady-state level, $\bar{B}^{i,j} / (\bar{R}^{i,i} \bar{Y}^i)$, which can be zero, and the interest rate $i_t^{i,j}$ will contain a markup on the interest rate that region- j residents would have to pay, i_t^j .⁸ The opposite is true for the term in brackets being positive.

2.6.2. Market clearing and the current account

Market clearing implies that total supply must equal total demand. Hence, for country a it holds that the entire production of country- a goods is used either domestically or internationally. Hence, taking into account capital utilization costs, it holds that

$$Y_t^a = C_t^{G,a} + I_t^{G,a} + C_t^{a,a} + I_t^{a,a} + \frac{n_b^a}{n_a^b} (C_t^{b,a} + I_t^{b,a}) + \frac{n_c^a}{n_a^c} (C_t^{c,a} + I_t^{c,a}) + \frac{\Gamma_t^a(u_t^a) K_{t-1}^a}{R_t^{a,a}}, \quad (18)$$

where $C_t^{G,a} + I_t^{G,a}$ is domestic public and $C_t^{a,a} + I_t^{a,a}$ domestic private consumption and investment demand, $(n_j^a / n_a^j) (C_t^{j,a} + I_t^{j,a})$, for $j = b, c$, is private foreign consumption and investment demand, expressed in per-capita terms, and $\Gamma_t^a(u_t^a) K_{t-1}^a / R_t^{a,a}$ are capital utilization costs. For the latter, we have to take into account that the cost function is expressed in CPI, while the rest of equation (18) is expressed in PPI-terms. An analogous equation holds for region b . Note further that, in line with national accounting, where public employment is added to private-sector production at factor costs (including social security contributions) to derive GDP, we define $GDP_t^a = Y_t^a + (1 + \tau u_t^{s,c,a}) w_t^{G,a} n_t^{G,a} / R_t^{a,a} - \Gamma_t^a(u_t^a) K_{t-1}^a / R_t^{a,a}$ following Stähler and Thomas (2012). Hence GDP_t^a is an adjunct accounting variable bringing GDP-figures from national accounts closer to those of our model. These differences in accounting are commonly neglected in most DSGE models in which private-sector output, Y_t^a , is generally equalized with GDP.

Given that we assume the third region c to be a VAR process in this paper, we can simplify the rest of the world's consumption and investment demand of country- j products, with $j = a, b$, to

$$C_t^{c,j} + I_t^{c,j} = n_j^c R_t^{c,j} (g^{c,c} + g^{c,i}) e^{\epsilon_t^{c,j}} Y_t^c,$$

where Y_t^c is the rest of the world output, described below, $g^{c,c}$ and $g^{c,i}$ are consumption and investment shares of this output, respectively, and $\epsilon_t^{c,j}$ is an exogenous AR(1) shock process for import preferences of country- j products. An analogous shock is included for intra-European trade (see equation summary for details).

Given international trade in goods *and* assets, we will also have to determine the net foreign asset position between all regions as it may be the case that some regions

⁸We have sneaked in here the reason, omitted in the discussion of the budget constraint (8), why home and foreign rates may differ.

produce more than they consume and, hence, build up international assets or vice versa – if not permanently, this is certainly the case temporarily across the cycle. Taking into account the real exchange rate between countries i and j , $rer_t^{i,j}$, to be defined below, as well as the bond trading structure described in the previous section, country a 's foreign bond position in country- a CPI terms can be expressed as

$$\underbrace{rer_t^{a,c} B_t^{a,c} + B_t^a}_{=nfa_t^a} = (1 + i_{t-1}^{a,c}) \frac{rer_t^{a,c} B_{t-1}^{a,c}}{\pi_t^c} + (1 + i_{t-1}^{b,a}) \frac{B_{t-1}^a}{\pi_t^a} \quad (19)$$

$$+ R_t^{a,a} Y_t^a - C_t^a - I_t^a - \Gamma_t^a(u_t^a) K_{t-1}^a - C_t^{G,a} - I_t^{G,a},$$

and for country b , in CPI-terms of country b , as

$$\underbrace{rer_t^{b,c} B_t^{b,c} + rer_t^{b,a} B_t^{b,a}}_{=nfa_t^b} = (1 + i_{t-1}^{b,c}) \frac{rer_t^{b,c} B_{t-1}^{b,c}}{\pi_t^c} + (1 + i_{t-1}^{b,a}) \frac{rer_t^{b,a} B_{t-1}^{b,a}}{\pi_t^a} \quad (20)$$

$$+ R_t^{b,b} Y_t^b - C_t^b - I_t^b - \Gamma_t^b(u_t^b) K_{t-1}^b - C_t^{G,b} - I_t^{G,b},$$

where it holds that $B_t^a = -(\mathcal{P}^a / \mathcal{P}^a) B_t^{b,a}$. Equations (19) and (20) state that each country can only consume as much as the sum of its own production and interest payments on outstanding asset holdings, or it will have to take up debt. In other words, the current account of country i , $ca_t^i = nfa_t^i - nfa_{t-1}^i$, is balanced if and only if country i consumes its entire production plus interest payments. Otherwise, the current account will, depending on the country's consumption stance, be positive or negative and country i 's net for foreign asset position, nfa_t^i , will naturally increase or decrease. Because bond markets also need to clear in equilibrium, it is straightforward to derive

$$B_t^c = - \left(\frac{\mathcal{P}^a}{\mathcal{P}^c} B_t^{a,c} + \frac{\mathcal{P}^b}{\mathcal{P}^c} B_t^{b,c} \right), \quad (21)$$

where it holds that $nfa_t^c = B_t^c$. For further reference, we note that, from the perspective of country a , the real exchange rate between regions are related as follows

$$rer_t^{c,a} = \frac{1}{R_t^{a,c}}, \quad rer_t^{c,a} = \frac{1}{rer_t^{a,c}} \quad \text{and} \quad rer_t^{b,c} = \frac{rer_t^{b,a}}{rer_t^{c,a}},$$

changes in the nominal exchange rate are given by

$$\Delta S_t^{a,c} = \frac{\pi_t^a (rer_t^{a,c} / rer_{t-1}^{a,c})}{\pi_t^c}$$

and it holds that $\pi_t^{a,c} = \pi^c \Delta S_t^{a,c}$. Realizing that analogous relations hold between all re-

regions a, b, c and remembering that, because of the monetary union assumption, it holds that $\Delta S_t^{a,b} = \Delta S_t^{b,a} = 1$ allows us to derive the remaining relations (see equation summary for a full account).

2.6.3. The rest of the world

In order to assess the question how much – also in relation to other shocks – discretionary fiscal policy in Germany and EMU affected German and EMU growth and unemployment rates – plus how much of that policy spilled over from Germany to EMU and vice versa –, a detailed modeling of the third region, representing the rest of the world, is not essential as long as we believe that spillovers from German and EMU fiscal policy to the rest of the world are relatively small and as long as we allow for the rest of the world to affect Germany and the rest of EMU. In this case, we can simplify the third-region to a structural vector autoregressive (SVAR) process similar Christiano et al. (2011), which greatly helps to make the estimation process more tractable. Hence, we assume the rest of the world is represented by the following three-equation SVAR process including rest-of-the-world output, \hat{Y}_t^c , inflation, $\hat{\pi}_t^c$, and interest rates, \hat{i}_t^c , in deviation from their steady state⁹ and with this ordering:

$$\begin{pmatrix} \hat{Y}_t^c \\ \hat{\pi}_t^c \\ \hat{i}_t^c \end{pmatrix} = \underbrace{\begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{pmatrix}}_{=AA} \begin{pmatrix} \hat{Y}_{t-1}^c \\ p\hat{i}_{t-1}^c \\ \hat{i}_{t-1}^c \end{pmatrix} + \underbrace{\begin{pmatrix} 1 & 0 & 0 \\ c_{2,1} & 1 & 0 \\ c_{3,1} & c_{3,2} & 1 \end{pmatrix}}_{=CC} \begin{pmatrix} v_t^{Y,c} \\ v_t^{\pi,c} \\ v_t^{i,c} \end{pmatrix}, \quad (22)$$

where $v_t^{Y,c}$, $v_t^{i,c}$ and $v_t^{\pi,c}$ are stochastic iid shocks with mean zero and variance $\sigma^{Y,c}$, $\sigma^{i,c}$ and $\sigma^{\pi,c}$, respectively. We will estimate these shocks as well as the matrices AA and CC . This completes the model description. We now turn to the model estimation.

3. Bayesian estimation

In this section, we describe how we estimate the model. In doing so, we first describe the data used and its transformation. Then, we state which parameters we calibrate and which we estimate with Bayesian techniques. For the latter, we state the priors and their distribution. Last, we show the results of estimating the model.

3.1. The data and shock processes

The specific structure of *GEAR* requires to construct a novel data set, one which goes beyond the available sources for studies on the Euro Area (see, for example, Fagan et al. 2005). The novelty comes in mainly for three reasons: an Euro Area aggregate without Germany; a relatively rich set of quarterly fiscal variables derived from sources where all we have is on an annual basis; and a coherent export and import matrix of

⁹In detail, $\hat{Y}_t^c = \log(Y_t^c / \bar{Y}^c)$, $\hat{\pi}_t^c = \pi_t^c - \bar{\pi}^c$ and $\hat{i}_t^c = i_t^c - \bar{i}^c$

flows between the blocks of countries. As always, with such an amount of data work, compromises are inevitable and the word “data”, in its original meaning as something given, is more or less stressed to the limit. Another criteria, especially when *GEAR* will be used as a supporting tool for medium- term projections at central banks and which may add to the list of compromises we have to make, is the ability to update the entire data set with a click of the mouse.

We focus on data over the sample period from 1999Q1 to 2012Q4 for nine of the initial EMU-11 countries: Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Portugal, and Spain. Measured on the basis of GDP (in PPP-shares) this group of nine covers about 92 percent of the 17 member states of the EMU.¹⁰ The chief sources for the various variables are the European System of Accounts (ESA) for the main aggregates and the *European Commission* for the fiscal variables.¹¹ The Rest of the World is a composite of eight large developed and emerging countries: Brazil, Canada, China, India, Japan, Russia, the United Kingdom, and the United States. As we setup the third country block in a simplified way as a SVAR we need to collect data only on GDP, inflation, and a short-term interest rate. For GDP and inflation we use indexes processed at the Bundesbank based on data from national statistical sources. The U.S. federal fund rate serves as a proxy for the interest rate. Table 1 has the detailed list of variables.¹²

Table 1 about here

GDP, private consumption, private investment, exports, wages, public consumption, public investment and transfers are in per capita terms and made real using the GDP deflator. To match these series with the model variables, we take first differences in logs and then sub-tract average GDP growth. The remaining series are demeaned. We have constructed the observable variables for $\tau^{sc,i}$, w^i and $C^{G,i}$ based on other available series in a model-consistent way. In particular, we have the $\tau^{sc,i} = \text{compensation of employees/wages and salaries} - 1$, $w^i = (\text{gross wages and salaries} - \text{compensation of government employees} / (1 + \tau^{sc,i})) / \text{private employment}$ and $C^{G,i} = \text{public spending} - \text{compensation of government employees}$. Due to data availability, transfers for the rest of Europe include unemployment benefits, whereas transfers for Germany are net of unemployment benefits. Note, further, that $I^i = \text{total} - \text{public investment}$ and $\text{Private employment} = \text{total} - \text{public employment}$.

To construct quarterly tax rates for labor, capital, and consumption for the nine Euro Area countries we interpolate the yearly figures published by the European Commission with a related series using the method of Chow and Lin (1971). Specifically, we exploit the relation with proxies for the respective tax bases: gross wages and income, the gross operating surplus, and private consumption. Since we work with tax bases as

¹⁰As of January 2014, after Latvia introduced the Euro, the EMU increased to 18 countries.

¹¹In particular, we take the taxation trends in the European Union from http://ec.europa.eu/taxation_customs/taxation/gen_info/economic_analysis/tax_structures/index_en.htm.

¹²The data including updated versions beyond 2012Q4 are available upon request.

proxies, we need to apply the Chow-Lin procedure twice. In a first step we interpolate quarterly revenues using either gross wages and income, the gross operating surplus, or private consumption. Having quarterly revenues, we can now divide them by the tax bases to get “implicit” quarterly tax rates which serve, in a second step, as the related series for the interpolation of yearly tax rates.

Compared to Coenen et al. (2013) and Forni et al. (2009) our approach for constructing quarterly fiscal series may seem a bit simplistic. Forni et al. (2009), for instance, use the formulas of Mendoza et al. (1994) and apply the Chow-Lin interpolation to the individual components in those formulas. Our simpler approach has two advantages: we need to collect less data on the country level and, more importantly, we build on yearly data actually used by institutions to discuss and compare the taxation trends in the European Union. A slight drawback, however, comes in when comparing our approach with Coenen et al. (2013) and their source of quarterly fiscal variables (see Parades et al., 2009). Using proxies for the Chow-Lin interpolation we may not capture “genuine” quarterly dynamics on the fiscal side. The reason why we do not resort to the database of Paredes et al. (2009), who advocated the construction of such genuine dynamics, lies in the non-institutionalized availability with a certain lag.

Now, compiling an Euro Area aggregate without Germany is straightforward for nominal variables or employment figures. To construct the respective price index we divide nominal and real GDP, taking care of the chain-index nature of real GDP when summing it up. For the variables in the Rest of the World block we aggregate real GDP and the price indexes by using the log-index method as in Fagan et al. (2005), i.e. $X = \exp(\sum_{i=1}^n w_i \log X_i)$; the Euro Area tax rates are simple weighted aggregates. The country weights, w_i , denote GDP-shares in PPP units normalized such that $\sum_{i=1}^n w_i = 1$.¹³

Another difficulty in our context is the construction of coherent import and export flows (divided in goods and services) between the three blocks: GER, RoE, and RoW. Technically, the problem reduces to a two-block problem because they automatically determine the third one. Since we approximate the RoW by a three variable VAR we focus here on Germany and the Rest of the Euro Area. The Bundesbank collects the flows from and to Germany with each trading partner (*Bbk Trade Balance*). So this part of the exercise is fairly simple. For all other countries, however, these bilateral flows of goods and services, for instance between France and Italy, are not readily available.¹⁴ Alternatively, we use aggregate data from the *ECB Trade- and BOP-Statistics*, besides the *Bbk Trade Balance*, to derive implicit trade shares in a first step. For the exports of France, as representative country of the Euro Area aggregate without Germany, we get these

¹³We take the shares w_i from the World Economic Output (Source: International Monetary Fund).

¹⁴Collecting detailed bilateral flows of goods and services from other national central banks or statistical agencies goes beyond the scope of the paper.

shares as follows (with the respective data sources in brackets):

$$\text{Export Goods GER} = \frac{\text{Import Goods GER from FRA}(\text{Bbk Trade Balance})}{\text{Total Export Goods}(\text{ECB Trade Statistic})},$$

$$\text{Export Services GER} = \frac{\text{Import Services GER from FRA}(\text{Bbk Trade Balance})}{\text{Total Export Services}(\text{ECB BOP Statistic})},$$

$$\text{Export Goods EUR} = \frac{\left(\text{Export Goods intra EMU-17}(\text{ECB Trade Statistic}) - \text{Import Goods GER from FRA}(\text{Bbk Trade Balance}) \right)}{\text{Total Export Goods}(\text{ECB Trade Statistic})},$$

$$\text{Export Services Goods EUR} = \frac{\left(\text{Export Services intra EMU-17}(\text{ECB BOP Statistic}) - \text{Import Services GER from FRA}(\text{Bbk Trade Balance}) \right)}{\text{Total Export Services}(\text{ECB BOP Statistic})},$$

In the same way we can construct the export flows for all other countries in our Euro Area aggregate and, likewise, the import flows. Having these shares we multiply, in a second step, the export and import data from the *European System of Accounts* to get the trade flows between the three blocks in the required form. One final adjustment is, however, still necessary. The approximation of the trade shares leads to some inconsistencies in the flows: exports from France to Germany may not be the same as imports of Germany from France. To align the flows we use the detailed data from the *Bbk Trade Statistics* to compute the “gap” in the following way:

$$\begin{aligned} \text{Gap Export FRA to GER} = & \text{Import GER from EUR} - \sum_{i=1}^N \left(\text{Export Goods EUR}_i \times \right. \\ & \text{Export-Share Goods EUR}_i / \text{GER} + \text{Export Services EUR}_i \times \\ & \left. \text{Export-Share Services EUR}_i / \text{GER} \right) \times \text{GDP-Share FRA/EUR}. \end{aligned}$$

After adding the gap, exports on one side of the boarder are perfectly aligned with imports on the other side.

In the model, the data is driven by 39 structural shocks. Except for the already described monetary and fiscal policy shocks, all shocks $\epsilon_t^{X,a}$ with $X \in \{A, \}$ follow AR(1) processes:

$$\epsilon_t^{X,a} = \rho^X X_{t-1} + v_t^X,$$

where v_t^X is an i.i.d. shock with mean zero and variance σ^X .

3.2. Calibration, prior selection and estimation results

The model is estimated with Bayesian techniques.¹⁵ We calibrate some parameters either by relying on values commonly chosen in the literature or by matching long-run targets in the data. These long-run targets can be found in Table 2. A summary of all calibrated parameters is displayed in Table 3. Note that we are able to solve for the (asymmetric) steady state analytically. The complete derivation is available on request.

3.2.1. Calibration

In the fiscal sector, we mainly target sample averages. This the case for tax rates and social security contribution rates, $\tau^{w,i}$, $\tau^{k,i}$, $\tau^{c,i}$, $\tau^{sc,i}$, public consumption and investment over GDP, $\frac{C^{G,i}}{GDP^i}$, $\frac{I^{G,i}}{GDP^i}$ as well as public employment over total employment $\frac{N^{G,i}}{N^i}$. Using unemployment benefits data for Germany, we can determine the sample average of the replacement ratio $\frac{UB^a}{w^a(1-\tau^{w,a})}$. We use the German estimate also for the rest of the euro area due to a lack of reliable data. Further, the markup of public wages over private wages, mg^i , is set to 3% for Germany and the rest of the euro area (see Fernández de Cordoba et al., 2012, and Afonso and Gomes, *forthcoming*). Finally, the steady state government debt to output ratio is set to 60% on an annual basis, consistent with the Maastricht criteria.

Table 2 about here

Regarding technology parameters, the capital share is set to the standard value of $\alpha_i = 0.33$. The rates of depreciation for private and public capital, δ and δ^G , are both set to 6% as in Coenen et al. (2013). We calibrate the parameters governing the influence of the public sector on the private production following Pappa (2009) and Leeper et al. (2009). This implies we set $\eta^{K^G,i} = 0.1$ and $\eta^{N^G,i} = 0.1$. In the steady state, we make sure that $\zeta^i(N^{G,i})\eta^{N^G,i}(K^{G,i})\eta^{K^G,i} = 1$ through an appropriate choice of the public sector productivity shifter, ζ^i . Hence, we neutralize the influence of the public sector in the steady state. This assumption greatly simplifies the calculation of the analytical steady state while leaving unchanged the dynamics of the model. Finally, we set the elasticity of substitution between intermediate goods, θ_i , to 4 implying a markup of roughly 33%. This value is in line with other studies for the euro area (see, for instance, Bayoumi et al., 2004). Finally, the value of fixed costs Ω_i is such that profits are zero in the steady state.

For the preference parameters, we assume that the utility function is logarithmic in consumption and set $\sigma_i = 1$. This is a common choice in the DSGE literature and increases comparability with other studies (see, for instance, Coenen et al., 2013). Further, we set $\beta_i = 0.9985$ which results – together with the assumed target inflation rate π of 1.9% (p.a.) – in a steady-state nominal interest rate i of 2.5% (p.a.) for the euro area as a whole. As in Coenen et al. (2013), the parameter determining the importance of private

¹⁵We use Dynare for the estimation and simulation of the model, see Adjemian et al. (2011) for details.

consumption versus public consumption, α_G^i , is chosen such that marginal utilities of private and public consumption are the same at the prior mode. The parameter influencing the Frisch elasticity of labor supply is set to $\varphi_i = 11$. These parameter values imply a “true” Frisch elasticity (at the extensive margin) of roughly 20% for Germany and the rest of the Euro Area.¹⁶ A Frisch elasticity of 20% lies in the range of values found by the literature (see Reichling, 2012 for a recent survey) and coincides with the estimate by Galí et al. (2011) whose model features a similar structure of the labor market. Finally, we calibrate population sizes based on total population figures.

Regarding the labor market, we target the steady state unemployment and employment rates. The labor disutility scaling parameter, κ^w , supports these targets. Given our previous calibration choices, the elasticity of substitution between different types of labor, θ_i^w , as well the wage markup are derived endogenously. $\theta_a^w = 7.5$ and $\theta_b^w = 6.0$ imply a wage markup of roughly 25% for Germany and 32% for the rest of Europe, where the wage markup is given by $w^i \lambda^i / (\kappa_a^w (N^a)^{\varphi_a} + UB^i \lambda^i (1 - \tau_i^w))$ in our model, which is in line with other studies for the euro area (see, for instance, Bayoumi et al., 2004).

For the international sector, we assume all relative prices and real exchange rates to be equal to one in the steady state. This assumption, while not being unrealistic, proves to be very helpful in calculating the asymmetric steady state. Net foreign asset positions are then determined endogenously. Finally, the risk premium parameter ϕ is set to 0.01 as in Coenen et al. (2008).

Table 3 about here

3.3. Prior selection

The first four columns of Tables 4 and 5 summarize our prior choices.¹⁷ In general, we make rather standard prior choices and follow the relevant literature. Regarding the shock processes, fiscal rules and monetary policy, we broadly follow the prior assumptions of the New Area-Wide Model (see Christoffel et al., 2008) and its fiscal extension (see Coenen et al. 2013). For friction and preference parameters, we mainly follow Forni et al. (2009) as our structure of the labor and goods market is similar to their structure. For instance, they also use Rotemberg pricing on both the goods and labor market. Prior assumptions of the VAR(1) describing the rest of the world are mainly in line with Christiano et al. (2011).

We would like to highlight, however, a few prior selections. Regarding the fiscal rules, our intention is to “let the data speak” given that size and sign of the coefficients crucially determine the importance of discretionary fiscal shocks. Therefore, we choose a normal distribution with mean zero and a variance of 1 for all reaction coefficients.

¹⁶Note that φ_i is not simply the inverse of the Frisch elasticity because of the existence of unemployment, public employment and unemployment benefits.

¹⁷Prior distributions are assumed to be the same for both countries. Therefore we suppress the country index in Tables 4 and 5.

We thus allow for potential procyclical or debt *destabilizing* reactions of single instruments.¹⁸ In the same vein, we employ a beta distribution for autoregressive coefficients with a mean of 0.5 and a relatively high variance of 0.2. Regarding wage and price adjustment costs, we follow Forni et al. (2009) and use a gamma distribution with a mean of 100 for both parameters. This corresponds in their model to an adjustment frequency of prices of approximately five quarters (in a world with Calvo pricing). Finally, we assume a normal distribution with mean one and a variance of 0.5 for the elasticity of substitution between private and government consumption, ν_G . Hence, a priori, we do not assume government consumption to have a crowding-in effect.

3.4. Posterior distributions

The main characteristics of the (marginal) posterior distributions are displayed in the last four columns of Tables 4 and 5. The posterior mode is found by maximizing the posterior kernel. Mean and confidence intervals are taken from the (marginal) posterior distributions which are based on two Markov chains with 400,000 draws (132,000 draws are discarded in a burn-in phase).

A detailed discussion of all estimation results seems beyond the scope of this paper. However, some results are noteworthy. First, posterior mode estimates of μ and $\bar{\mu}$ are sizeable in both countries. Hence, transfer shocks have an important impact in our model. Second, the estimates of ν_G suggest that public consumption and private consumption are strong complements, more so in Germany. Together with the sizeable point estimates of μ and $\bar{\mu}$, this result implies strong crowding-in effects of government consumption. Third, fiscal instruments, in particular tax, social security contributions and public employment rates, exhibit high persistence as the point estimates of the autoregressive coefficients indicate. While this is an intuitive result, it is also a closely related to the way we transform the data for tax, social security or employment rates: That is, we do not detrend these variables as it is usually the case tax rates or employment variables in the literature (see Forni et al., 2009). To the extent that these variables exhibit some trending behavior – especially in the case of public employment in Germany – it is reflected in the estimate of the autoregressive coefficient. Fourth, fiscal instruments in general are debt-stabilizing where lump sum taxes in the rest of Europe are an exception, however. Note that this result might reflect the fact that no data on lump sum taxes is used in the estimation and we use these to fit the deficit-to-GDP ratio. Fifth, there is only weak evidence for automatic stabilization behavior in the fiscal rules in both countries. One reason may be that one important automatic stabilizer, namely unemployment benefits, is already modeled explicitly. Interestingly, public investment is – although very imprecisely – estimated to react in a procyclical way in both countries.

Tables 4 and 5 about here

¹⁸Note that positive debt reaction coefficients always indicate a debt stabilizing behavior.

4. Quantitative assessment

We now use the estimated model to assess (discretionary) fiscal policy in Germany and the rest of the Euro Area in the past decade and to assess how big was fiscal policy's impact on GDP growth during the crisis. We also calculate fiscal multipliers resulting from our model. In doing so, we first conduct an impulse response analysis for selected shocks to improve the understanding of how the model and some of its fiscal features work. Based on this analysis, we, then, calculate the size of the fiscal multipliers resulting in our model. Following this analysis, we conduct a historical shock decomposition in order to evaluate how much fiscal policy conducted in Germany and the rest of the Euro Area affected GDP growth and how large were the intra-European spillovers of fiscal policy. We also show a theoretical variance decomposition in order to shed more light on the role of different shocks.

4.1. *Impulse response analysis*

The main innovations of our model compared to other large-scale DSGE models on the market are the complex labor market structure (including the unemployment insurance being an automatic stabilizer) as well as the fairly detailed fiscal sector, plus the interactions of these innovations with the rest of the economy. In order to understand how these features affect the economy, we conduct an impulse response analysis for selected shocks concentrating on some of these features. To be precise, we show the effects of two standard shocks, namely a technology and a monetary policy shock, and show how the effects in our baseline model differ from those when setting unemployment benefits or the share of rule-of-thumb consumers to zero in Figure 2 and 3. In order to better understand the fiscal side of the model, we shock different public revenue variables in Figure 4, while the effects of shocking different public spending components are shown in Figure 5.

The impulse response functions of a 1% technology shock in Germany are shown in Figure 2. We see that they are quite standard. More precisely, we observe an increase in GDP, consumption, investment and real wages in Germany. Employment falls and unemployment increases. Inflation also falls. Hence, the increase in productivity, on the one hand, allows firms to decrease employment (to produce the same amount of output *ceteris paribus*) and makes them decrease producer prices. These effects are standard and are described in more detail in, for example, Galí (2013) who also contrasts the effects of the New Keynesian framework used here to those of the standard neoclassical model. Because of the fall in employment, the labor income tax base deteriorates (which cannot be compensated for by higher wages) and payments for unemployed workers increase. This dampening effect on public finances cannot be overcompensated by better consumption revenues, for which the debt-to-GDP ratio increases for a while until it starts falling again. Lower prices improve Germany's terms of trade vis-a-vis the rest of the Euro Area. Still, spillovers of a positive technology shock in Germany to the rest of the Euro Area are positive. Higher consumption and investment demand in Germany

also fosters demand for products from this region, which implies an increase in production, investment and employment there. Wage income also increases, which fosters private consumption as well as public balances and produces some inflationary pressure. However, spillovers tend to be small, especially on prices, for which the monetary policy rate reacts only very little. The effects after such a supply-side shock differ very little when shutting off unemployment benefits or the existence of RoTs.

Figure 2 about here

Turning to a monetary policy shock, we also observe standard effects; see Figure 3. The increase in the monetary policy rate reduces domestic demand, where private investment falls more strongly than private consumption because of the temporary increase in the real interest rate. Following the decline in aggregate demand, output drops and firms cut back their demand for labor. Unemployment increases. The resulting decrease in wages makes firms cut producer prices via the impact on marginal costs, which finally feeds through to the consumer price index. Less employment, lower wages, higher unemployment and lower demand deteriorate fiscal balances and the debt-to-GDP ratio increases. These effects hold for both regions, Germany and the rest of the Euro Area. According to our estimates, the overall decline in producer prices seems somewhat stronger and more persistent in Germany than in the rest of the Euro Area, which improves Germany's terms of trade vis-a-vis the Euro Area. Qualitatively, there are again no difference whether unemployment benefits and RoTs exist or not. However, we note that, while the existence of RoTs still produces only minor differences to our estimated baseline, the existence of unemployment benefits now makes a more notable difference. In the presence of unemployment benefits, the drop in real wages is larger than without unemployment benefits, which stabilizes employment a bit. As the income loss when being unemployed is lower than without the existence of benefits, aggregate demand is stabilized and the output is less pronounced. While the deterioration of public finances is somewhat stronger in presence of unemployment benefits at the beginning, the effect dies out after about eight quarters because of the demand-stabilizing effects.

Figure 3 about here

On the fiscal revenue side, we simulate shocks to the labor income, capital and consumption tax rates in Germany shown in Figure 4. All tax rates are raised so as to produce an increase of 1% of the primary-deficit-to-GDP ratio on impact, while thereafter, the fiscal rules are allowed to work as estimated. All tax rate hikes imply a decrease in the German debt-to-GDP ratio. An increase in the labor income and consumption tax rates imply a drop in private consumption because of less net income and higher policy-induced consumption taxes, respectively. Whenever the capital tax rate is increased, private consumption increases. The latter follows from the fact that, as capital investments become less attractive, optimizing households shift from investment to consumption

demand. Still, aggregate demand falls in all cases. Thus, output deteriorates and the firms' labor demand falls. This implies a fall in real wages for an increase in the capital and consumption tax rates. Because the labor income tax rates enters the wage bargaining game, households want to be compensated for the higher labor tax rates at least partly. Hence, they demand higher (gross) wages whenever the labor income tax rate is increased. Via the marginal costs channel, this makes firms reduce prices whenever consumption and capital tax rates are increased, while they increase prices for a hike of the labor income tax rate. These prices feed through to consumer prices. Naturally, this implies an improvement of Germany's terms of trade for the two former cases, while they deteriorate in the latter. Spillovers to the rest of the Euro Area tend to be small and negative due to the decreased aggregate demand in Germany. The monetary policy rate reacts very little as price changes are small and opposite in both regions. All tax shocks imply that the Germany's and the rest of the Euro Area's terms of trade vis-a-vis the rest of the world increase, except for the labor income tax shock for Germany. This implies that exports into region c increase slightly, which is not shown in the graphs, however. Given the relatively small fall in Germany's demand from rest of the Euro Area after a capital tax rate increase (indicated by the smaller drop in output on impact), the increase in the rest of the world's demand for rest of Euro Area products overcompensates the decrease in German demand for those products. Hence, output in the rest of the Euro Area initially rises. This effect, however, dies out after about three years.

Figure 4 about here

For the government spending side, we simulate the standard shock to public purchases, $C_t^{G,a}$, and contrast this to a shock to public employment and public investment, see Figure 5. All shock are such that public expenditures increase by 1% of GDP on impact, while the fiscal rules are, again, allowed to work as estimated. The effects of a shock to government purchases are standard. Higher public demand has to be produced by firms, which increases output. Unemployment falls, generating upward pressure on wages. Via the marginal costs channel, this raises prices. Because of RoT consumers, private consumption demand increases, while private investment demand crowded-out. The debt-to-GDP ratio increases on impact, but improves shortly after due to the relatively large multiplier of such a government spending shock. Whenever the positive impact of this spending shock dies out, debt starts rising again (see, among others, Colciago et al., 2008, for similar results). Because of price increases, German terms of trade vis-a-vis the rest of the Euro Area deteriorate. This, plus higher private consumption demand in Germany increase the demand for rest of Euro Area products, consequently increasing output, employment, wages, consumption, investment and prices there. As price hikes are relatively small, the monetary policy rates reacts very little, but increases. We observe similar effects of an increase in public investment. However, given that public investment increases the public capital stock, which affects private-sector productivity positively, private investment demand now also increases. This policy-induced positive "productivity" shock has similar effects on

employment and prices as those of a pure technology shock described earlier. Hence, prices now decrease (slightly) and private employment improves less than in the case of a pure public purchases shock. The remaining effects are analogous to what has been described already. A shock to public employment in Germany also increases German GDP, private sector-productivity, real wages, public debt and prices, and it reduces unemployment. The shock is more persistent, which can be attributed to the high estimate of the autocorrelation coefficient. In contrast to the other shocks, we observe a drop in private consumption and investment in Germany, as well as negative demand-driven spillovers to the rest of the Euro Area. Hence, we have a fall in aggregate German demand, even though GDP rises. Note, however, that the rise in GDP is nothing but an accounting effect as Figure 6 shows. Remember that we define GDP in line with national accounting as $GDP_t^a = Y_t^a + (1 + \tau u_t^{sc,a}) w_t^{G,a} n_t^{G,a} / R_t^{a,a} - \Gamma_t^a(u_t^a) K_{t-1}^a / R_t^{a,a}$, which is private-sector output plus public wage bill (including social security contributions) minus capital utilization costs. Hence, an increase in public employment increases GDP, but it reduces private-sector output and private employment (which is overcompensated by the increase in public employment). Because of higher real wages, it is less attractive for firms to hire workers, and, via the marginal costs channel, they increase prices. Because higher public employment has to be financed eventually, the wealth effect inducing optimizers to decrease private consumption (and investment) dominates the private consumption pattern.¹⁹ Hence, spillovers to the rest of the Euro Area are now negative driven by the negative demand effect in Germany. This analysis reveals that, when talking about government spending shocks or multipliers, it is crucial to define which spending component one refers to, and whether or not the multiplier's base is GDP or private sector output (the latter potentially being especially relevant for empirical analyses).

Figures 5 and 6 about here

4.2. Fiscal multipliers

Based on the analysis of the previous section, it is now straightforward to calculate fiscal multipliers resulting in our model. In doing so, we follow Leeper et al. (2010) and calculate a present-value multiplier for each fiscal shocks for the first four years. We differentiate between the GDP and private-sector output multiplier. To capture the spillovers from Germany to the rest of the Euro Area and vice versa, we present the multipliers of both regions. The results are summarized in Table ??.

Table ?? about here [to be included]

¹⁹Also note that private-sector productivity increases after both a public investment and a public employment shock. However, for a public employment shock, this cannot compensate the negative wealth effect and, thus, private investment demand and output fall in contrast to shock to public investment.

4.3. *Historical shock decomposition*

In this section, we present a historical shock decomposition of (demeaned) real GDP growth to assess how much fiscal policy and which other shocks contributed to output evolution during the crisis period from 2008Q1 to 2011Q4. We do this separately for Germany and the rest of the Euro Area (figures of the historical shock decomposition for the entire estimation period are available upon request). Having identified fiscal policy's role on GDP growth, we will dig a bit deeper and assess which fiscal policy shocks emerged during that period.

Figure 7 depicts the historical shock decomposition showing fiscal and non-fiscal shocks for Germany (Panel 7a) and the rest of the Euro Area (Panel 7b). It suggests that discretionary fiscal measures indeed pushed up quarter-on-quarter GDP growth during the crisis, up to about 0.4% in Germany in 2009Q1 and to about 0.2% in the rest of the Euro Area in 2009Q2. In terms of annualized quarter-on-quarter growth rates, this implies a contribution of 1.6% for Germany and 0.8% for the rest of the Euro Area, which is in line with Coenen et al. (2012, 2013). We further see that discretionary fiscal measures barely affected German GDP growth in the consolidation phase, while they dampened GDP growth in the rest of the Euro Area up to about -0.3% in 2010Q1. However, GDP growth was mainly driven by something else than discretionary fiscal policy, again in line with Coenen et al. (2012, 2013). In addition to their analysis, we are able to differentiate between different regions within EMU. Those findings naturally raise two questions: what were the drivers of GDP growth and which fiscal policy instruments contributed to the fiscal impact just described?

Figure 7 about here

In order to address the first question, Figure 8 depicts the same shock decomposition as before except that, now, we split the non-fiscal shocks into shocks from the rest of the world, risk premium shocks, monetary policy shocks and domestic and foreign non-fiscal shocks (such as, for example, productivity shocks, preference shocks and so on) as indicated in the figures. We note that discretionary monetary policy, in general, positively contributed to German and rest of Euro Area growth rates, which seems plausible given the accommodating stance of monetary policy during that period. Rest of the world shocks were the main driver for the slump in Germany GDP in 2008 and the beginning of 2009, see Panel 9a, but they were also the main driver of the recovery of German GDP starting in 2009Q2. The second most important driver in Germany was a risk premium shock, followed by other domestic non-fiscal shocks (amongst them, technology shocks seemed most important). Domestic non-fiscal as well as rest of the world shocks contributed most to German GDP growth in the period after 2010Q1, but at a much lower level than during the crisis. It seems noteworthy that non-fiscal shocks from the rest of the Euro Area played only a minor role for the evolution of German GDP growth, while rest of Euro Area fiscal shocks are entirely negligible (their largest impact on the German GDP growth rate was 0.03% in 2010Q1). The picture is somewhat different in the rest of the Euro Area, shown in Panel 9b. Here, the main driver for the

GDP slump in 2008 and beginning of 2009 were domestic non-fiscal shocks, followed by negative risk premia shocks. Also negative non-fiscal shocks in Germany contributed to the decline in Euro Area GDP growth. The impact of the rest of the world shocks on rest of Euro Area growth rates was, compared to their impact on German growth rates, rather small. This allows for the conclusion that Germany is more trade-dependent on the rest of the world and is less affected by (non-fiscal) shocks in the Euro Area, while the rest of the Euro Area depends more on what happens in Germany domestically. Regarding spillovers of discretionary German fiscal policy to the rest of the Euro Area, they are also negligibly small (amounting to a maximum impact of 0.02% on the rest of the Euro Area growth rate). A noteworthy difference between German and rest of Euro Area growth rates is that, at the end of our sample period, negative domestic non-fiscal shocks in the rest of the Euro Area seem to pick up, while German GDP growth stays rather stable. This analysis, hence, shows that spillovers between Germany and the rest of the Euro Area are mainly due to non-fiscal shocks, while spillovers of fiscal policy were rather small. This adds to the impulse response analysis of the previous section also which hints at spillovers of domestic fiscal policy to be small.

Figure 8 about here

The second question, which fiscal shocks contributed to the fiscal impact on GDP growth rates, is addressed in Figure 9. The bold black line represents the contribution fiscal policy had on GDP growth, equivalent to the blue bars in Figure 7. We split this contribution into the components taxes and social security contributions, transfers, public investment and public spending, the latter including public purchases and expenditures for public employment. We see that, in Germany, the positive fiscal growth impact in 2008 and 2009 was mainly driven by positive shocks to public spending and investment and, to a lesser extend, tax reliefs. In 2009, positive transfers shocks also contributed notably. This corresponds to the time in which the investment and redemption fund was established to foster public investment (2008 and the following years) and in which several public transfer schemes were founded, such as, for example, the car scrap bonus programme in 2009, public parental leave subsidies (starting in 2007, but mainly started to being used in the years thereafter), an increase in social benefits or the short-time work allowances programme. Regarding the positive impact of taxes and social security contributions on GDP growth in Germany during that time, we observed a cut in social security contributions (mainly to the health insurance system), an expansion of tax exemptions as well as an increase in possibilities for tax deductions, all of which are partly still in place today. Around 2010, also German fiscal policy started to be more restrictive, partly to also comply with the debt brake put in German constitution. This tighter fiscal stance was mainly expenditure driven. Hence, when contrasting our findings with actual measures conducted, the historical shock decomposition for Germany gives a plausible picture.²⁰ For the rest of the Euro Area, it is harder to relate the

²⁰Note that we picture the contribution of each fiscal component to GDP growth rates. This does

shock decomposition to concrete policy measures because we observe an aggregate of the rest of the Euro Area and measures were quite different in the corresponding countries. However, we can also note that most of the fiscal stimulus programmes that were put in place started in mid 2008 and lasted until about the end of 2009 before consolidation started had a positive contribution to the GDP growth rates. Stimulus programmes contained expenditure hikes and tax cuts. The historical shock decomposition based on our estimates for the rest of the Euro Area suggests that, overall, tax cuts had most positive impact on GDP growth during that time. Beginning of 2010, the fiscal situation in many of the rest of the Euro Area countries deteriorated, room for fiscal stimulus was narrowed and some countries started consolidating already. We see this in the negative fiscal stance in 2010Q1. Expenditure cuts were most responsible for the negative impact on GDP growth then. In the remainder of the year 2010, the overall fiscal stance was somewhat neutral as was its contribution to GDP growth in the Euro Area. The main fiscal consolidation phase started around 2011, which lies beyond our sample period.

Figure 9 about here

A more disaggregated decomposition for the fiscal shock and a decomposition of the contribution of foreign shocks to the domestic growth rate (i.e. a decomposition of German fiscal policy's contribution to rest of Euro Area's growth rates and vice versa) are available upon request.

5. Conclusions

In this paper, we presented the estimated three-region DSGE model *GEAR*, which pictures Germany, the Euro Area and the Rest of the world and which is used by the Deutsche Bundesbank for policy analysis. We use the model to analyze how discretionary fiscal policy in Germany and the rest of EMU affected GDP growth and unemployment during the crisis. Not surprisingly, stimulus programmes positively affected domestic GDP growth rates while consolidation measures had a negative impact. The contribution of fiscal policy on domestic GDP growth was only small, however, amounting to a maximum of 1.6% for Germany and 0.8% for the rest of the Euro Area in terms of annualized quarter-on quarter growth rates. The main driver for the evolution of GDP were rest of the world and risk premia shocks, followed by domestic non-fiscal shocks, amongst them the technology shock being the most important one. Spillovers of fiscal policy shocks are negligibly small, which holds for spillovers of fiscal shocks in Germany to the rest of the Euro Area and vice versa. This latter finding is confirmed by an impulse-response analysis and by calculating the corresponding multipliers. Hence,

not necessarily correspond to the size of the fiscal shock or the measure, respectively. For example, a tax decrease only mildly affecting public balances may have a higher contribution than a comparatively large increase in public spending.

relating these findings to current discussions, our analysis suggests that domestic fiscal policy has little effects on the other regions' GDP within EMU and can, therefore, contribute only little to solving the imbalances problem.

Tables and Figures

Table 1: List of observables

Germany and Euro Area	Rest of the World
GDP (GDP^i)	real GDP (GDP^c)
GDP deflator (π^{ii})	GDP deflator (π^c)
Euribor, 3-month (i^{EA})	U.S. Fed funds rate (i^c)
private consumption of nondurables and services (C^i)	
private investment incl. durable goods (I^i)	
exports to the rest of Europe/Germany (EX^i)	
private employment rate ($N^{P,i}$)	
unemployment rate (u^i)	
private gross wages and salaries per head (w^i)	
public employment rate ($N^{G,i}$)	
public consumption ($C^{G,i}$)	
public investment ($I^{G,i}$)	
transfers (TR^i)	
public deficit ratio (def^i)	
SSC rate (employer) ($\tau^{sc,i}$)	
labor tax rate ($\tau^{w,i}$)	
capital tax rate ($\tau^{k,i}$)	
consumption tax rate ($\tau^{c,i}$)	

Note: GDP^i , $i = a, b$, is defined as $GDP^i = Y^i + \frac{N^{G,i}w^{G,i}(1+\tau^{sc,i})}{R^{i,i}} - \frac{\Gamma^i K_{-1}^a}{R^{i,i}}$, EX^i is defined as $EX^a = \frac{n_b^a}{n_a^a} (C_t^{b,a} + I_t^{b,a})$ and $EX^b = \frac{n_a^b}{n_b^b} (C_t^{a,b} + I_t^{a,b})$ and def^i is defined as $def^i = \frac{\Delta B^{G,i}}{R^{i,i}GDP^i}$.

Table 2: Targeted steady-state values

Target variable	Value	
	Germany	Rest of euro area
Fiscal policy		
Labor income taxes, τ_w	0.38	0.379
Capital taxes, τ_k	0.218	0.322
Consumption taxes, τ_c	0.193	0.193
SSC (employers), τ_{sc}	0.234	0.328
Public consumption ratio, $\frac{C^G}{GDP}$	0.064	0.081
Public investment ratio, $\frac{I^G}{GDP}$	0.016	0.028
Public employment ratio, $\frac{N^G}{N}$	0.228	0.231
Transfers (incl. UB benefits) ratio, $\frac{TR+(L-N)UB}{GDP}$	0.174	0.170
Replacement ratio, $\frac{UB}{w(1-\tau^w)}$	0.4	0.4
Public markup, mg	0.03	0.03
Government debt ratio (quarterly), $\frac{B^G}{GDP}$	2.4	2.4
Monetary policy		
Inflation rate (quarterly), π		0.0045
Interest rate (quarterly), i		0.00475
Labor and goods market		
Unemployment rate, U	0.083	0.093
Employment rate, N	0.484	0.431
Wage markup	0.25	0.32
Frisch elasticity	0.2	0.2
Price markup	0.33	0.33
International sector		
Relative prices and real exchange rates		1

Table 3: Calibrated parameters

Parameter	Value	
	Germany	Rest of euro area
Preferences		
Intertemporal elasticity of substitution, σ	1	1
Discount factor, β	0.9985	0.9985
Importance of private consumption, α_G	0.89	0.85
Parameter influencing Frisch elasticity, φ	11	11
Labor disutility scaling parameter, κ^w	3274.5	8064.3
Population size, \mathcal{P}	1	2.6
Trade openness, ϑ_b^a and ϑ_a^b	0.95	0.95
Trade openness (vis-a-vis RoW), ϑ_c^a and ϑ_c^b	0.15	0.15
Technology		
Capital share, α	0.33	0.33
Rate of depreciation (private), δ	0.015	0.015
Rate of depreciation (public), δ^G	0.015	0.015
Output elasticity w.r.t. public capital, η^{K^G}	0.1	0.1
Output elasticity w.r.t. public employment, η^{N^G}	0.1	0.1
Public sector productivity shifter, ζ	1.21	1.18
Subs. Elasticity: intermediate goods, θ	4	4
Subs. Elasticity: different types of labor, θ^w	7.5	6
Fixed costs, Ω	0.35	0.31
International sector		
Risk premium parameter, ϕ		1

Table 4: Priors and posteriors for Germany

Parameter	Prior distribution	Posterior distribution			
		Mode	Mean	5%	95%
<i>Preferences</i>					
Share of RoT households, μ	B(0.5,0.1)	0.2699			
Distribution of transfers, $\bar{\mu}$	B(0.5,0.1)	0.4856			
Subs. elasticity: pr. and gov. cns., ν_G	N(1,0.5)	0.3231			
Habit formation, h	B(0.7,0.1)	0.6263			
Subs. elasticity: home and foreign goods, η	G(1.5,0.25)	0.7379			
<i>Frictions</i>					
Capital utlization costs, ψ^k	G(0.2,0.1)	0.1034			
Investment adj. costs, v	G(5,0.25)	4.9472			
Price adj. costs, v^p	G(100, $\sqrt{1000}$)	69.9708			
Wage adj. costs, v^w	G(100, $\sqrt{1000}$)	79.8398			
Price indexation, ξ	B(0.75,0.1)	0.3856			
Wage indexation, ξ^w	B(0.75,0.1)	0.5474			
<i>AR coefficients (fiscal rules)</i>					
Labour taxes, ρ_{τ_w}	B(0.5,0.2)	0.9605			
Capital taxes, ρ^{τ_k}	B(0.5,0.2)	0.9645			
Consumption taxes, ρ^{τ_c}	B(0.5,0.2)	0.9517			
SSC (employer), $\rho_{\tau_{sc}}$	B(0.5,0.2)	0.9009			
Public consumption, ρ_{CG}	B(0.5,0.2)	0.7847			
Public investment, ρ_{IG}	B(0.5,0.2)	0.6023			
Public employment, ρ_{NG}	B(0.5,0.2)	0.9879			
Transfers, ρ_{TR}	B(0.5,0.2)	0.9223			
Lump sum taxes, ρ_T	B(0.5,0.2)	0.423			
<i>Debt feedback coefficients (fiscal rules)</i>					
Labour taxes, ξ^{b,τ^w}	N(0,1)	0.0082			
Capital taxes, ξ^{b,τ^k}	N(0,1)	0.0944			
Consumption taxes, ξ^{b,τ^c}	N(0,1)	0.0194			
SSC (employer), $\xi^{b,\tau^{sc}}$	N(0,1)	-0.0174			
Public consumption, $\xi^{b,g}$	N(0,1)	-0.0249			
Public investment, $\xi^{b,IG}$	N(0,1)	0.6685			
Public employment, $\xi^{b,NG}$	N(0,1)	0.0003			
Transfers, $\xi^{b,TR}$	N(0,1)	0.1329			
Transfers, $\xi^{b,T}$	N(0,1)	0.446			

Table 4: Priors and posteriors for Germany (continued)

Parameter	Prior distribution	Posterior distribution			
		Mode	Mean	5%	95%
<i>Output feedback coefficients (fiscal rules)</i>					
Labour taxes, ξ^{y,τ^w}	N(0,1)	0.0156			
Capital taxes, ξ^{y,τ^k}	N(0,1)	0.0744			
Consumption taxes, ξ^{y,τ^c}	N(0,1)	0.012			
SSC (employer), $\xi^{y,\tau^{sc}}$	N(0,1)	-0.0047			
Public consumption, $\xi^{y,g}$	N(0,1)	0.0644			
Public investment, ξ^{y,I^G}	N(0,1)	0.3262			
Public employment, ξ^{y,N^G}	N(0,1)	-0.0047			
Transfers, $\xi^{y,Tr}$	N(0,1)	-0.0442			
Transfers, $\xi^{y,T}$	N(0,1)	0.0089			
<i>Monetary Policy</i>					
Interest rate smoothing, ρ_i	B(0.9,0.05)	0.8626			
Reaction to inflation, ϕ_π	N(1.7,0.05)	1.7452			
Reaction to output, ϕ_y	N(0.1,0.05)	0.1742			
<i>AR coefficients (non-fiscal shocks)</i>					
Technology, ρ_A	B(0.75,0.1)	0.9222			
Investment-specific technology, ρ_I	B(0.75,0.1)	0.5998			
Preference, ρ_β	B(0.75,0.1)	0.6826			
Labour disutility, ρ_N	B(0.75,0.1)	0.9686			
Risk premium EA, $\rho_{RP,EA}$	B(0.75,0.1)	0.7802			
Risk premium RoW, $\rho_{RP,RoW}$	B(0.75,0.1)	0.6683			
Price markup, ρ_θ	B(0.75,0.1)	0.7097			
Wage markup, ρ_{θ^w}	B(0.75,0.1)	0.7139			
Export preference RoE, ρ_{RoE}	B(0.75,0.1)	0.888			
Export preference RoW, ρ_{RoW}	B(0.75,0.1)	0.8847			

Table 4: Priors and posteriors for Germany (continued)

Parameter	Prior distribution	Posterior distribution			
		Mode	Mean	5%	95%
<i>Standard deviations</i>					
Technology, σ_A	IG(0.01,2)	0.0084			
Investment-specific technology, σ_I	IG(0.01,2)	0.0594			
Preference, σ_β	IG(0.01,2)	0.0198			
Labour disutility, σ_N	IG(0.01,2)	0.0259			
Risk premium EA, $\sigma_{RP,EA}$	IG(0.01,2)	0.0045			
Risk premium RoW, $\sigma_{RP,RoW}$	IG(0.01,2)	0.0061			
Price markup, σ_θ	IG(0.01,2)	0.0661			
Wage markup, σ_{θ^w}	IG(0.01,2)	0.1495			
Export preference RoE, σ_{RoE}	IG(0.01,2)	0.0593			
Export preference RoW, σ_{RoW}	IG(0.01,2)	0.0284			
Interest rate, σ_i	IG(0.001,2)	0.0009			
Labour taxes, σ_{τ_w}	IG(0.001,2)	0.0012			
Capital taxes, σ^{τ_k}	IG(0.001,2)	0.0047			
Consumption taxes, σ^{τ_c}	IG(0.001,2)	0.0013			
SSC (employer), $\sigma_{\tau_{sc}}$	IG(0.001,2)	0.0024			
Public consumption, σ_{CG}	IG(0.01,2)	0.0204			
Public investment, σ_{IG}	IG(0.01,2)	0.0597			
Public employment, σ_{NG}	IG(0.0001,2)	0.0003			
Transfers, σ_{TR}	IG(0.01,2)	0.0072			
Transfers, σ_T	IG(0.01,2)	0.031			

Table 5: Priors and posteriors for the rest of the Euro Area and the rest of the world

Parameter	Prior distribution	Posterior distribution			
		Mode	Mean	5%	95%
<i>Preferences</i>					
Share of RoT households, μ	B(0.5,0.1)	0.3316			
Distribution of transfers, $\bar{\mu}$	B(0.5,0.1)	0.4198			
Subs. elasticity: pr. and gov. cns., ν_G	N(1,0.5)	0.6246			
Habit formation, h	B(0.7,0.1)	0.7765			
Subs. elasticity: home and foreign goods, η	G(1.5,0.25)	0.7379			
<i>Frictions</i>					
Capital utlization costs, ψ^k	G(0.2,0.1)	0.1562			
Investment adj. costs, v	G(5,0.25)	4.8892			
Price adj. costs, v^p	G(100, $\sqrt{1000}$)	109.7796			
Wage adj. costs, v^w	G(100, $\sqrt{1000}$)	89.8512			
Price indexation, ξ	B(0.75,0.1)	0.4307			
Wage indexation, ξ^w	B(0.75,0.1)	0.3566			
<i>AR coefficients (fiscal rules)</i>					
Labour taxes, ρ_{τ_w}	B(0.5,0.2)	0.9419			
Capital taxes, ρ^{τ_k}	B(0.5,0.2)	0.9277			
Consumption taxes, ρ^{τ_c}	B(0.5,0.2)	0.8951			
SSC (employer), $\rho_{\tau_{sc}}$	B(0.5,0.2)	0.8126			
Public consumption, ρ_{CG}	B(0.5,0.2)	0.8898			
Public investment, ρ_{IG}	B(0.5,0.2)	0.593			
Public employment, ρ_{NG}	B(0.5,0.2)	0.9099			
Transfers, ρ_{TR}	B(0.5,0.2)	0.8708			
Lump sum taxes, ρ_T	B(0.5,0.2)	0.2342			
<i>Debt feedback coefficients (fiscal rules)</i>					
Labour taxes, ξ^{b,τ^w}	N(0,1)	0.0002			
Capital taxes, ξ^{b,τ^k}	N(0,1)	0.0022			
Consumption taxes, ξ^{b,τ^c}	N(0,1)	0.0083			
SSC (employer), $\xi^{b,\tau^{sc}}$	N(0,1)	0.0004			
Public consumption, $\xi^{b,g}$	N(0,1)	0.1422			
Public investment, ξ^{b,I^G}	N(0,1)	0.3025			
Public employment, ξ^{b,N^G}	N(0,1)	0.0023			
Transfers, $\xi^{b,TR}$	N(0,1)	0.0833			
Transfers, $\xi^{b,T}$	N(0,1)	-0.1956			

Table 5: Priors and posteriors for the rest of the Euro Area and the rest of the world
(continued)

Parameter	Prior distribution	Posterior distribution			
		Mode	Mean	5%	95%
<i>Output feedback coefficients (fiscal rules)</i>					
Labour taxes, ξ^{y,τ^w}	N(0,1)	-0.0004			
Capital taxes, ξ^{y,τ^k}	N(0,1)	0.0074			
Consumption taxes, ξ^{y,τ^c}	N(0,1)	0			
SSC (employer), $\xi^{y,\tau^{sc}}$	N(0,1)	-0.0149			
Public consumption, $\xi^{y,g}$	N(0,1)	-0.1212			
Public investment, ξ^{y,I^G}	N(0,1)	0.3564			
Public employment, ξ^{y,N^G}	N(0,1)	-0.0015			
Transfers, $\xi^{y,Tr}$	N(0,1)	-0.1283			
Transfers, $\xi^{y,T}$	N(0,1)	-0.3487			
<i>Monetary Policy</i>					
Interest rate smoothing, ρ_i	B(0.9,0.05)	0.8626			
Reaction to inflation, ϕ_π	N(1.7,0.05)	1.7452			
Reaction to output, ϕ_y	N(0.1,0.05)	0.1742			
<i>AR coefficients (non-fiscal shocks)</i>					
Technology, ρ_A	B(0.75,0.1)	0.9247			
Investment-specific technology, ρ_I	B(0.75,0.1)	0.5542			
Preference, ρ_β	B(0.75,0.1)	0.7044			
Labour disutility, ρ_N	B(0.75,0.1)	0.9498			
Risk premium EA, $\rho_{RP,EA}$	B(0.75,0.1)	0.5678			
Risk premium RoW, $\rho_{RP,RoW}$	B(0.75,0.1)	0.6152			
Price markup, ρ_θ	B(0.75,0.1)	0.7802			
Wage markup, ρ_{θ^w}	B(0.75,0.1)	0.6683			
Export preference GER, ρ_{GER}	B(0.75,0.1)	0.9475			
Export preference RoW, ρ_{RoW}	B(0.75,0.1)	0.8415			

Table 5: Priors and posteriors for the rest of the Euro Area and the rest of the world
(continued)

Parameter	Prior distribution	Posterior distribution			
		Mode	Mean	5%	95%
<i>Standard deviations</i>					
Technology, σ_A	IG(0.01,2)	0.0046			
Investment-specific technology, σ_I	IG(0.01,2)	0.0694			
Preference, σ_β	IG(0.01,2)	0.0203			
Labour disutility, σ_N	IG(0.01,2)	0.0264			
Risk premium EA, $\sigma_{RP,EA}$	IG(0.01,2)	0.0045			
Risk premium RoW, $\sigma_{RP,RoW}$	IG(0.01,2)	0.0061			
Price markup, σ_θ	IG(0.01,2)	0.0766			
Wage markup, σ_{θ^w}	IG(0.01,2)	0.1571			
Export preference GER, σ_{GER}	IG(0.01,2)	0.0279			
Export preference RoW, σ_{RoW}	IG(0.01,2)	0.04			
Interest rate, σ_i	IG(0.001,2)	0.0009			
Labour taxes, σ_{τ_w}	IG(0.001,2)	0.0008			
Capital taxes, σ^{τ_k}	IG(0.001,2)	0.0035			
Consumption taxes, σ^{τ_c}	IG(0.001,2)	0.0012			
SSC (employer), $\sigma_{\tau_{sc}}$	IG(0.001,2)	0.0014			
Public consumption, σ_{CG}	IG(0.01,2)	0.0076			
Public investment, σ_{IG}	IG(0.01,2)	0.0448			
Public employment, σ_{NG}	IG(0.0001,2)	0.0002			
Transfers, σ_{TR}	IG(0.01,2)	0.0067			
Transfers, σ_T	IG(0.01,2)	0.0104			
<i>Rest of the world (VAR)</i>					
a_{11}	B(0.75,0.1)	0.801			
a_{12}	N(0,1)	0.2746			
a_{13}	N(0,1)	0.1652			
a_{21}	N(0,1)	-0.0612			
a_{22}	B(0.75,0.1)	0.5994			
a_{23}	N(0,1)	0.1067			
c_{21}	N(0,1)	0.5252			
a_{31}	N(0,1)	0.0025			
a_{32}	N(0,1)	-0.0315			
a_{33}	B(0.9,0.1)	0.9536			
c_{31}	N(0,1)	0.0905			
a_{32}	N(0,1)	-0.0459			
Technology, σ_A	IG(0.01,2)	0.0071			
Inflation, σ_π	IG(0.01,2)	0.0055			
Interest rate, σ_i	IG(0.001,2)	0.0012			

Figure 1: Model overview

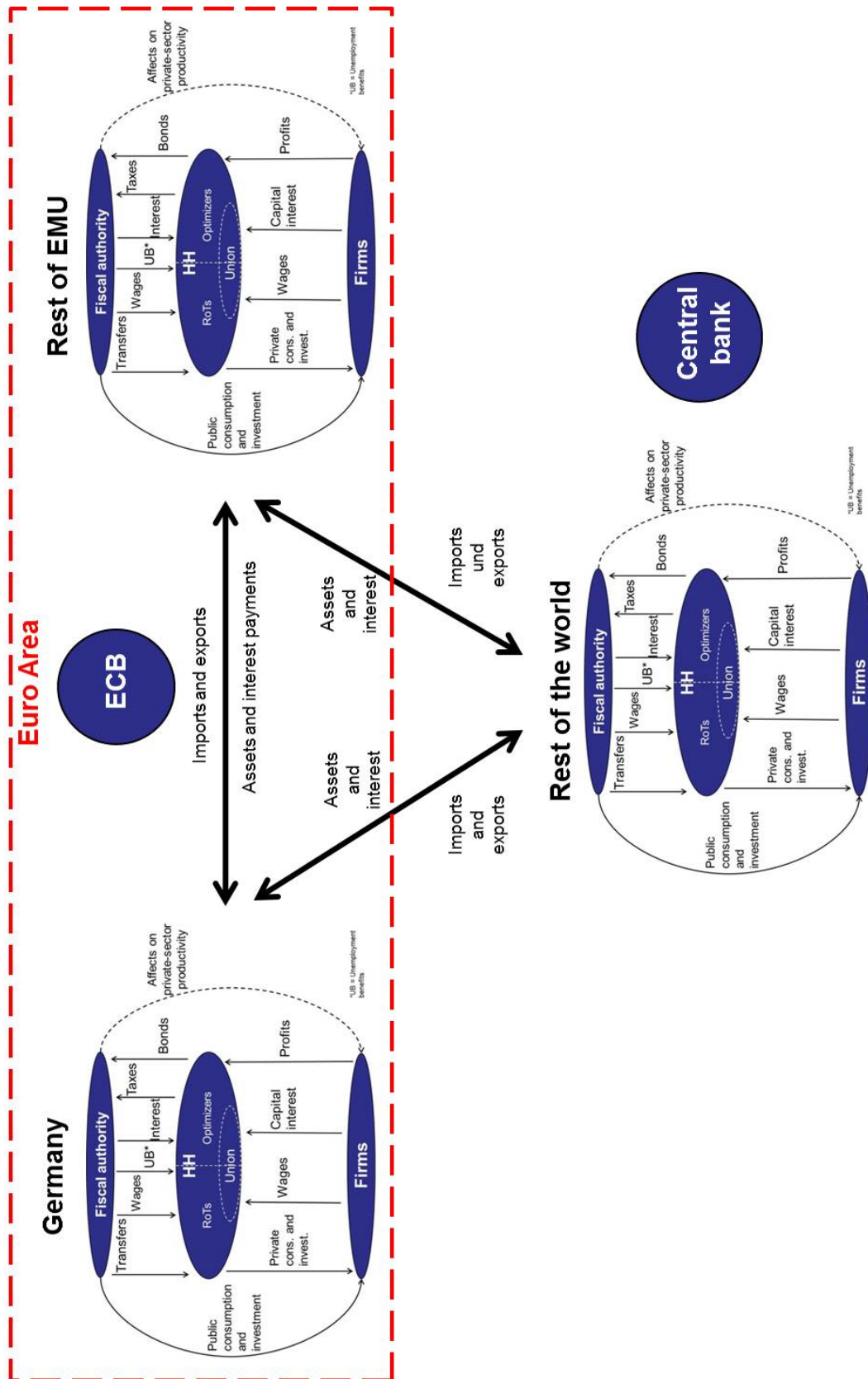
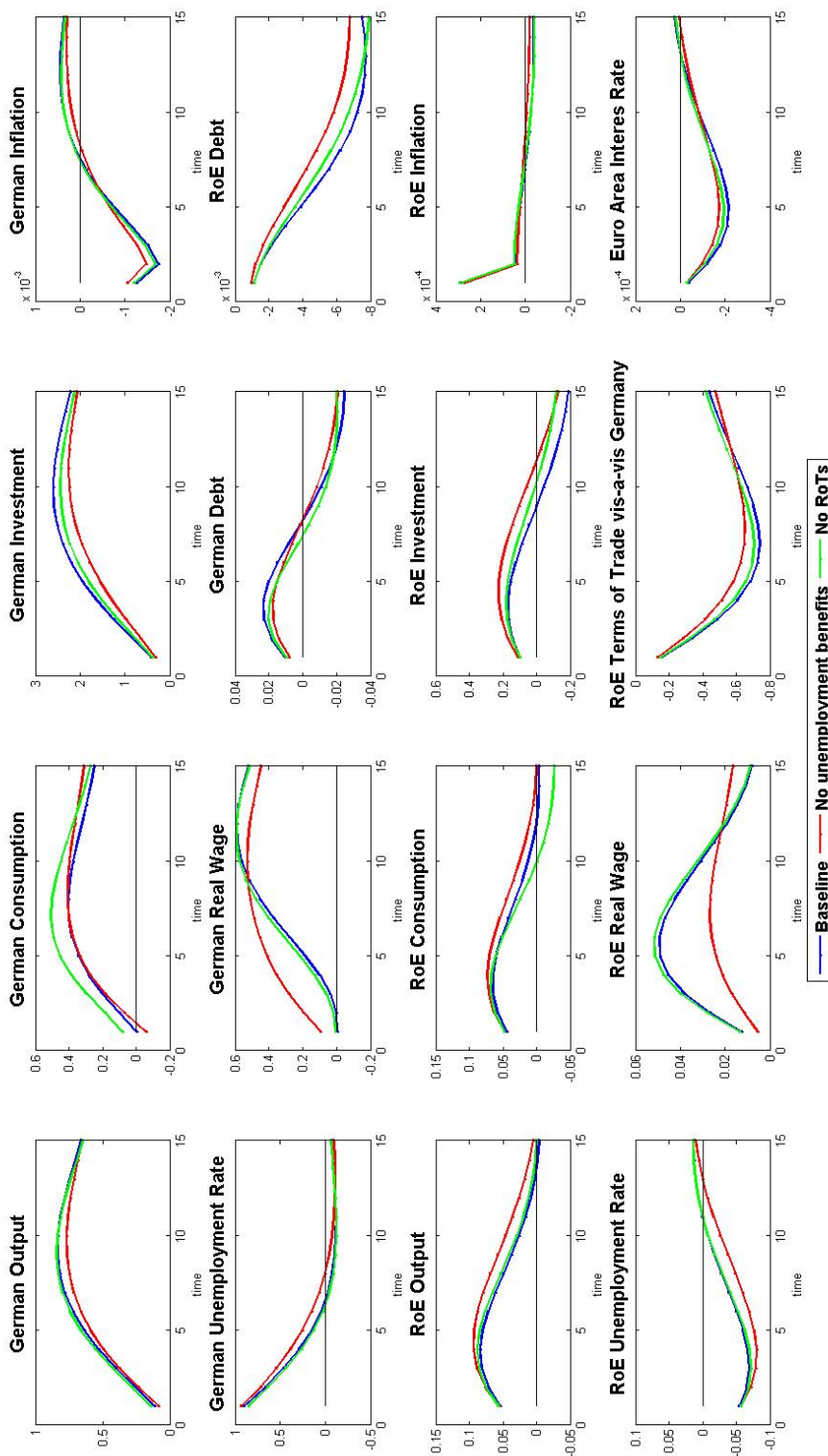
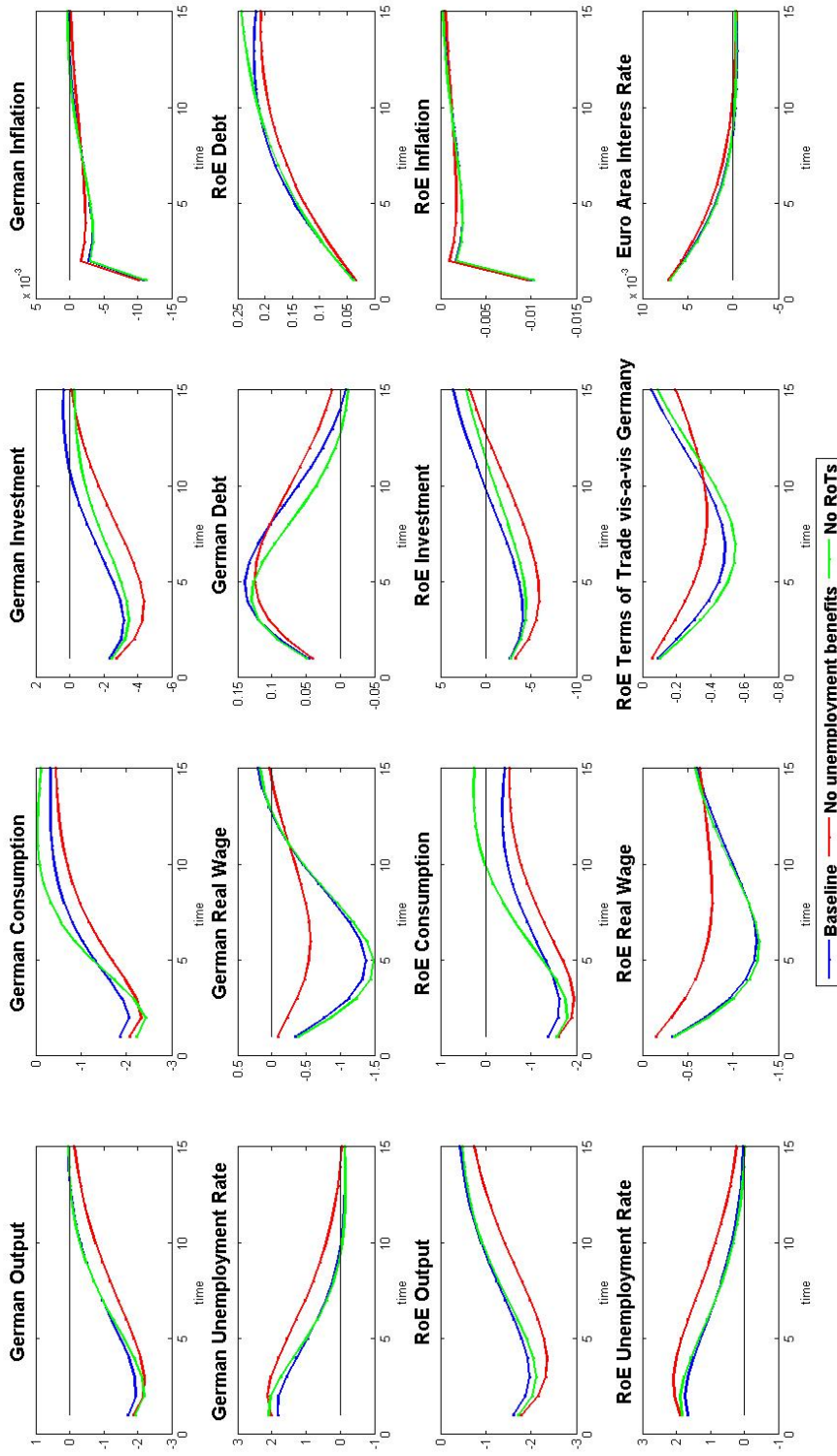


Figure 2: Impulse response functions to a technology shock



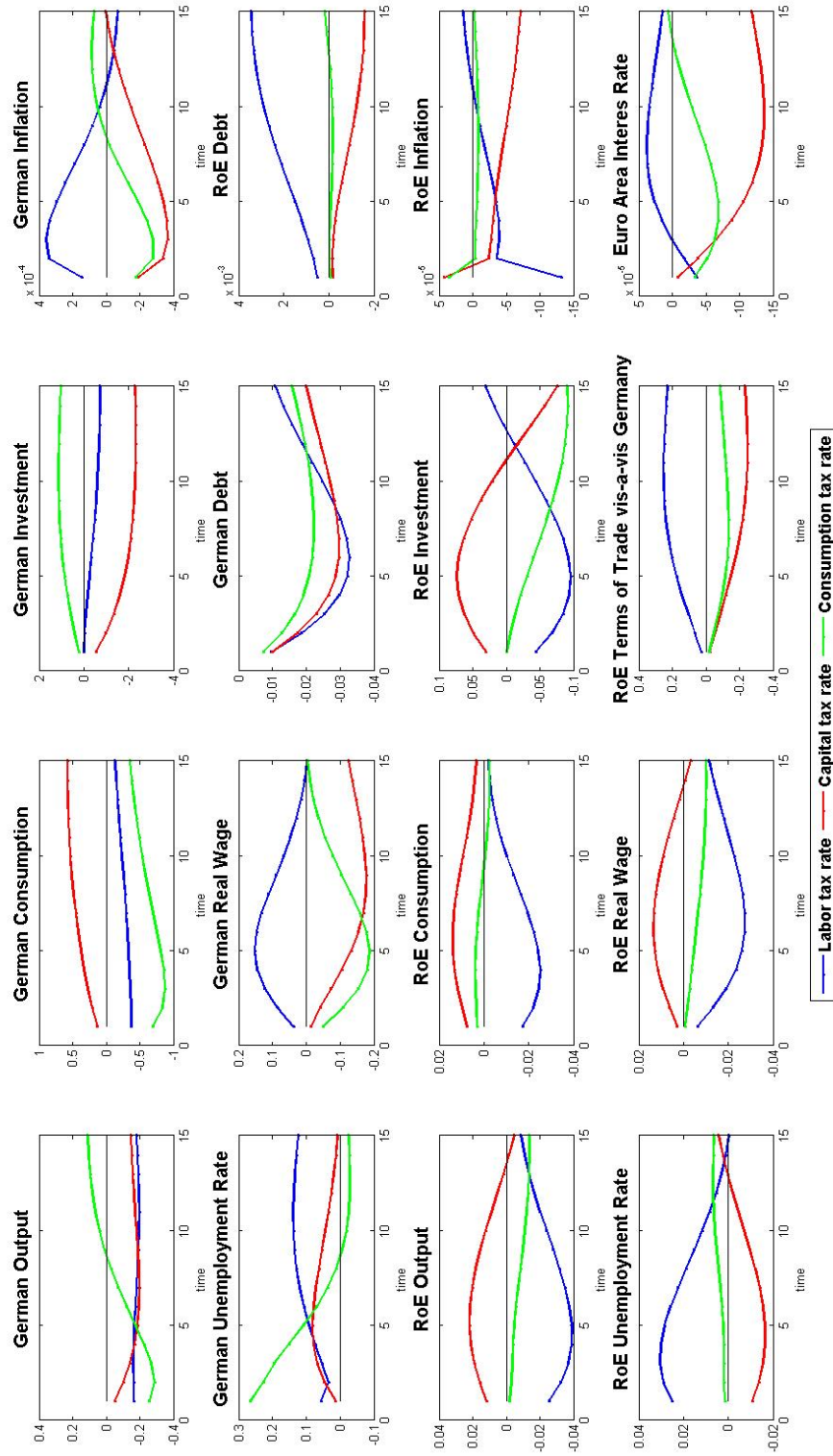
Notes: Figure shows impulse response functions of selected variables to a 1% technology shock. All deviations in percent to steady-state values (percentage point deviations for unemployment and interest rates as well as debt-to-GDP ratios).

Figure 3: Impulse response functions to a monetary policy shock



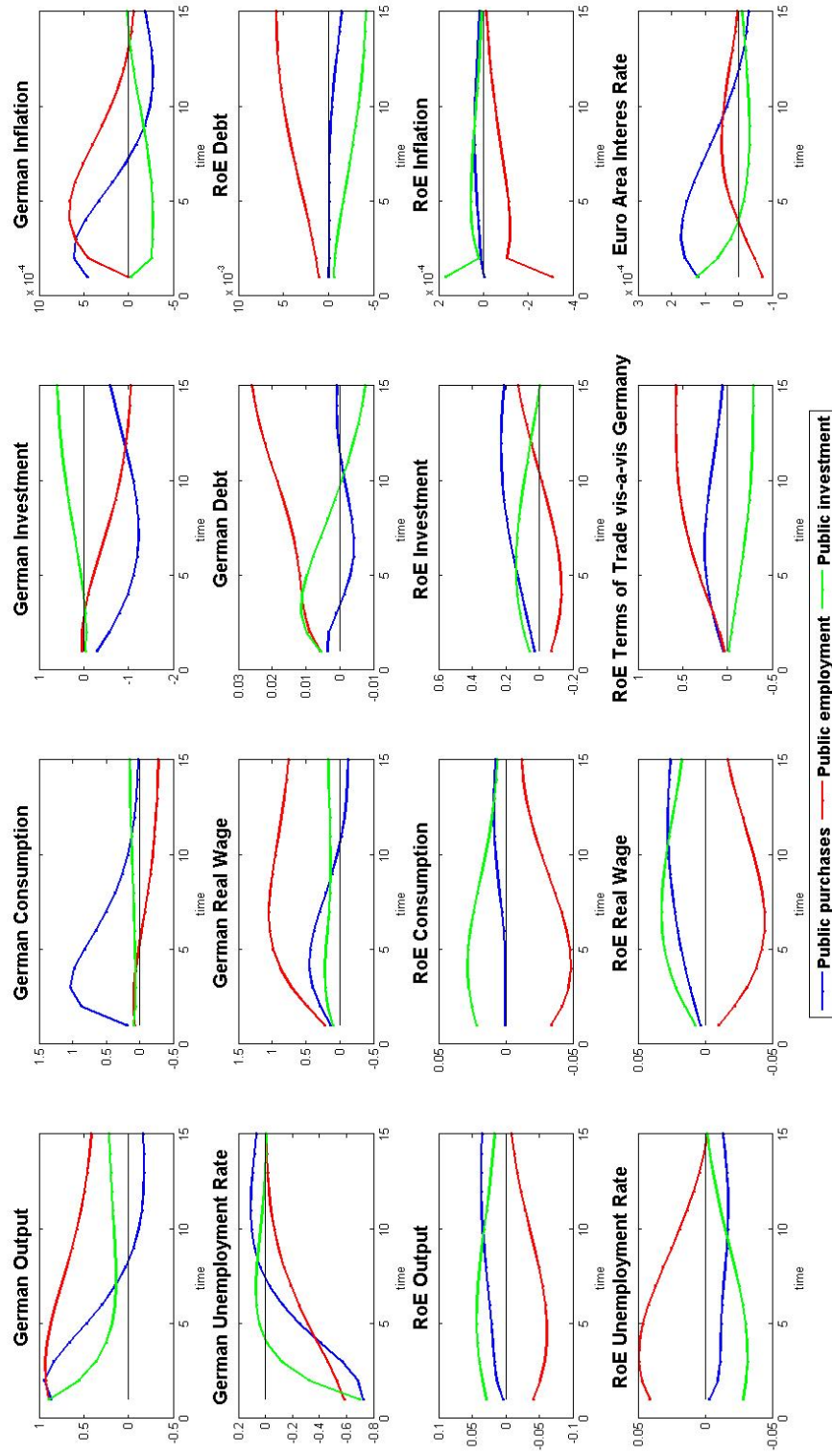
Notes: Figure shows impulse response functions of selected variables to a monetary policy shock. All deviations in percent to steady-state values (percentage point deviations for unemployment and interest rates as well as debt-to-GDP ratios).

Figure 4: Impulse response functions to selected fiscal revenue shocks



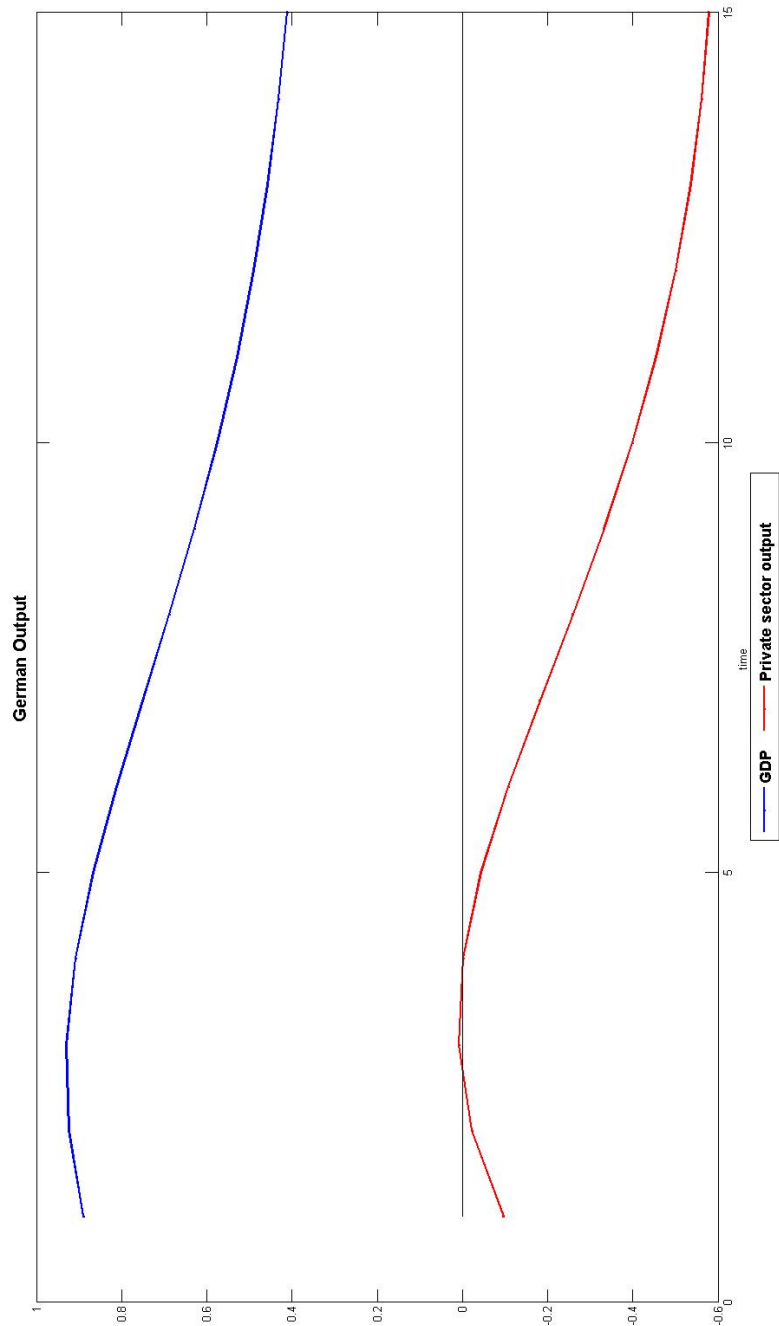
Notes: Figure shows impulse response functions of selected variables to a tax rate shock as indicated increasing the primary deficit-to-GDP ratio by 1%. All deviations in percent to steady-state values (percentage point deviations for unemployment and interest rates as well as debt-to-GDP ratios).

Figure 5: Impulse response functions to selected fiscal spending shocks



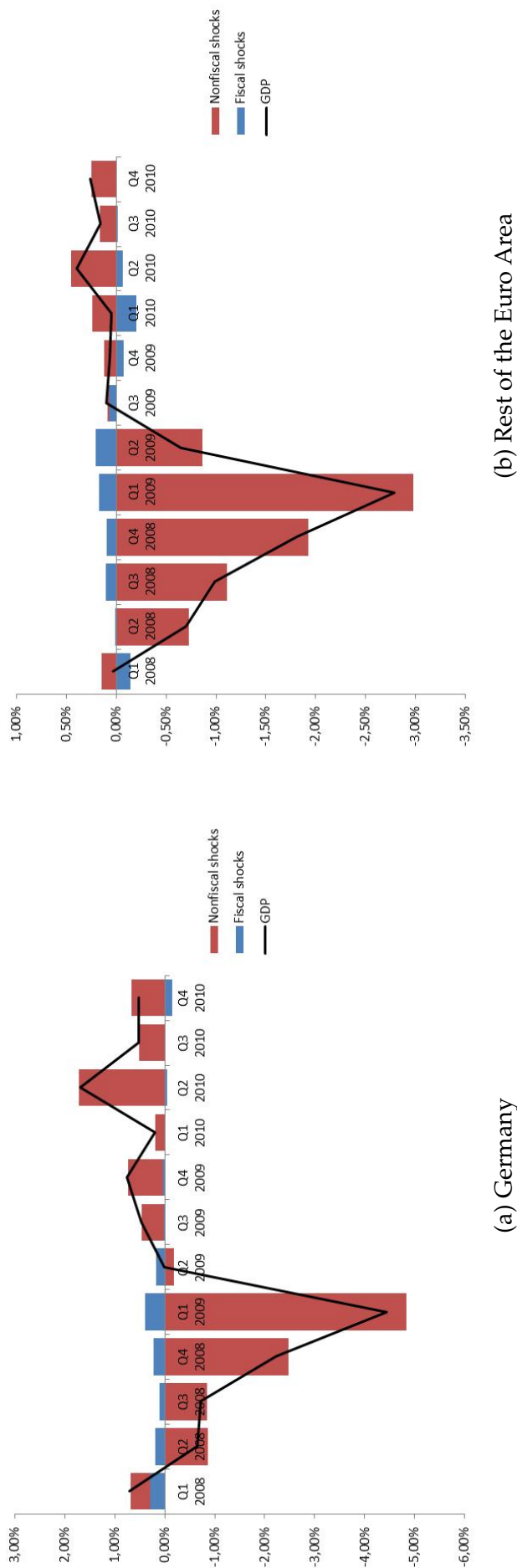
Notes: Figure shows impulse response functions of selected variables to a public spending shock as indicated decreasing the primary deficit-to-GDP ratio by 1%. All deviations in percent to steady-state values (percentage point deviations for unemployment and interest rates as well as debt-to-GDP ratios).

Figure 6: Comparing GDP and private production after a public employment shock



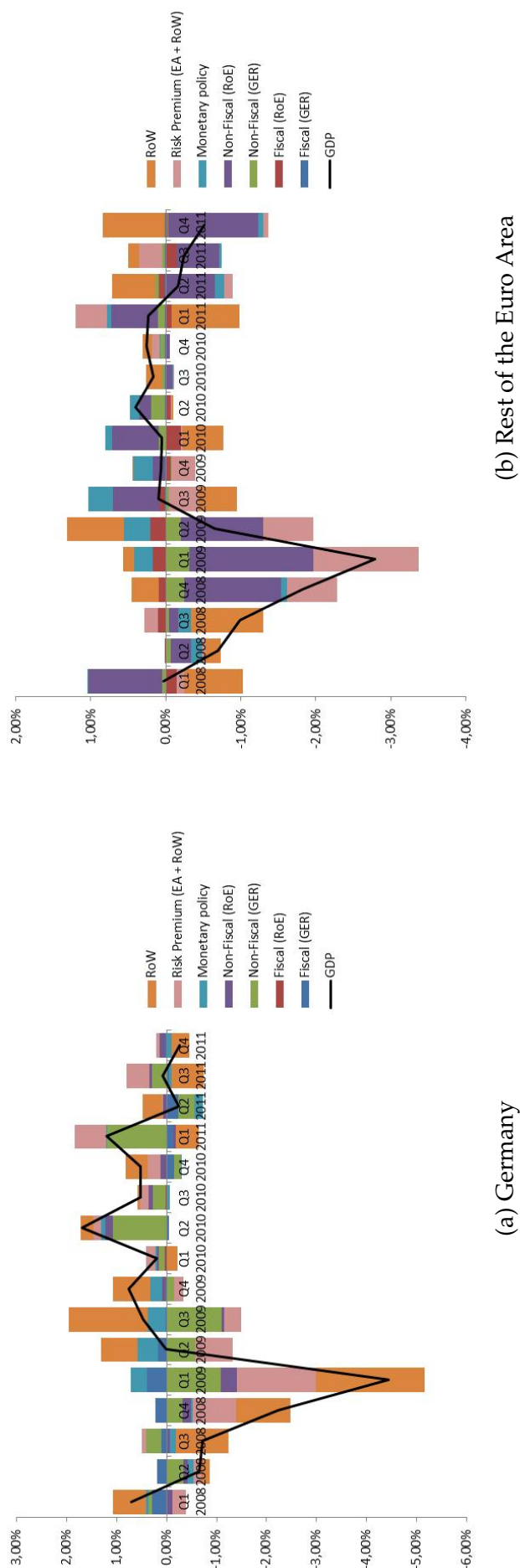
Notes: Figure compares impulse response functions of German GDP and private-sector output after a shock to public employment in Germany. Deviations are in percent to steady-state values, where $GDP_t^a = Y_t^a + (1 + \tau_{sc,t}^a) w_t^{G,a} n_t^{G,a} / R_t^{a,a} - \Gamma_t^a(u_t^a) K_{t-1}^a / R_t^{a,a}$.

Figure 7: Historical decomposition of real GDP growth (demeaned): Fiscal versus non-fiscal shocks



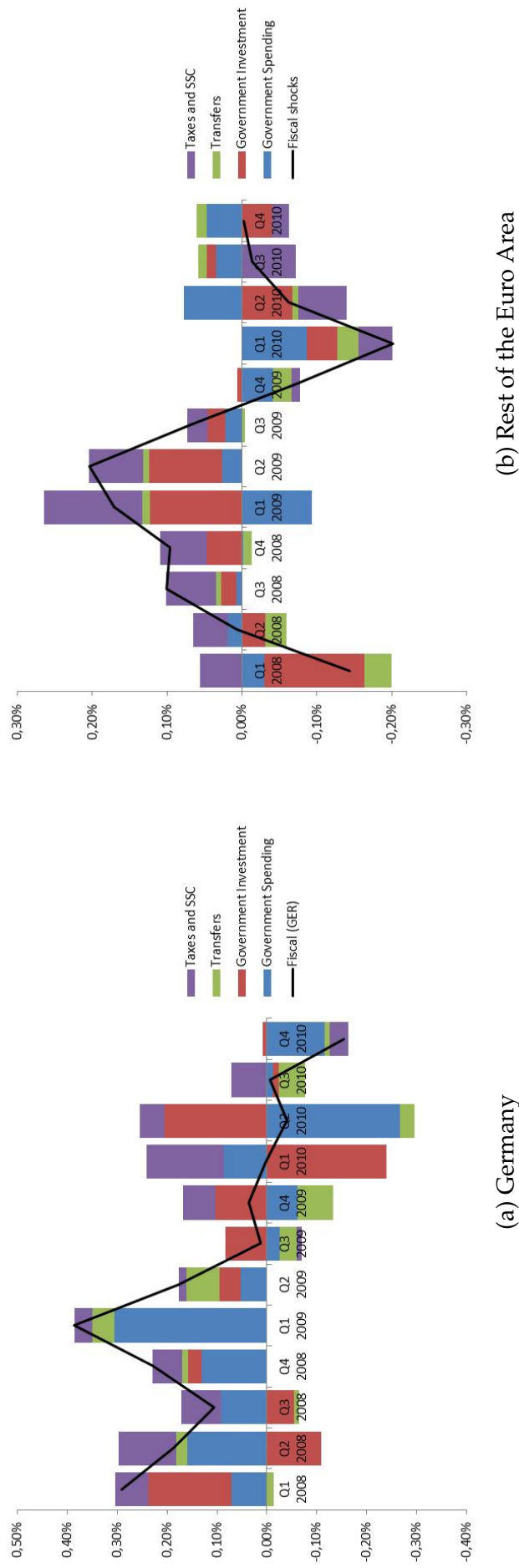
Notes: Figure shows quarter-to-quarter GDP growth rates (demeaned) and the contribution of fiscal and non-fiscal shocks to these developments. To annualize, rates have to be multiplied by four. The mean/trend growth rate in our sample period is 0.3% for Germany and $xx\%$ for the rest of the Euro Area.

Figure 8: Historical decomposition of real GDP growth (demeaned): Disaggregated shocks



Notes: Figure shows quarter-to-quarter GDP growth rates (demeaned) and the contribution of fiscal and disaggregated non-fiscal shocks to these developments. To annualize, rates have to be multiplied by four. The mean/trend growth rate in our sample period is 0.3% for Germany and xx% for the rest of the Euro Area.

Figure 9: Historical decomposition of fiscal policy's contribution to real GDP growth (demeaned)



Notes: Figure shows fiscal policy's contribution to quarter-to-quarter GDP growth rates (demeaned); disaggregated growth contribution by fiscal components. To annualize, rates have to be multiplied by four. The mean/trend growth rate in our sample period is 0.3% for Germany and xx% for the rest of the Euro Area.

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