A Two-Country Dynamic Stochastic Disequilibrium Model for a Currency Union.*

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Abstract

The Dynamic Stochastic Dis-Equilibrium model introduced by Schoder (2017b) is extended to a two-country version. Both countries are members of a monetary union. In the symmetric model calibration, effects of a domestic fiscal policy, a common monetary policy, a domestic productivity shock, and a domestic wage bargaining shock are analyzed and impulse responses provided for both the domestic and foreign economy. In the asymmetric calibration, two distinct wage bargaining regimes (corporatist and conflictive) are attributed to the two countries. The corporatist economy generally fares better due to a superior external trade performance when faced with similar shocks. Finally, introducing a feedback from the trade balance to the wage formation process stabilizes the system.

Keywords: Dynamic stochastic disequilibrium, labor market disequilibrium, labor rationing, collective wage bargaining, monetary policy
JEL Classification: B41, E12, J52

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1 Introduction

During the first two decades of the European Monetary Union, internal current account imbalances between Member States have seen a noticeable change in research interest. From it inception until the beginning of the Euro crisis, it was widely believed that current account imbalances between Member States have become irrelevant – comparable to current account differences between individual states in a nation state with a common currency. Moreover, while the build-up of the imbalances was noticed, the overwhelming opinion was that they were "good" imbalances, coinciding at least to an extent to catching up-processes a la Balassa-Samuelson. With the onset of the Euro crisis came the uncertainty over a possible EMU break-up: In the absence of exchange rates to bet against, government bond yields slumped precisely in those Southern European countries (plus Ireland) that had built up large external debt as a result of long-lasting current account deficits. Policymakers' view towards internal imbalances began to shift despite the lender of last resort guarantees by the European Central Bank. At the European Union level, an additional surveillance mechanism, the Macroeconomic Imbalances Procedure, was introduced by the European Commission. Eventually, with massive austerity programs planned either by the TROIKA or fearful nation states themselves, European policy embarked on an unprecedented adjustment effort and succeeded within a couple years to bring down the current account deficits in Southern Europe.[1] However, the corresponding surpluses of some Northern European countries, in particular Germany and the Netherlands, remained untouched. While their geographical origin shifted from Southern Europe that had compressed its import demand to countries outside of the monetary union, their level in terms of GDP has increased even further.

Both of these experiences highlight the enormous persistence that current account imbalances display within the European Monetary Union, even for countries that are on a similar technological level and share several industries. A number of channels have been identified that have contributed to the build-up of current account balances and, at least for the Northern countries, to their failure to revert back to the mean. The *income channel* ultimately refers to differences in relative growth rates. In DSGE models, the shock to government spending in the core has a high domestic multiplier effect if the economy is stuck in a liquidity trap and monetary policy is accomodative.[2] The larger the domestic shock, the larger will be the spillover effect to the foreign periphery economy via the income channel. From the point of view of a domestic (Northern economy), if the foreign (Southern European) economy achieves higher growth rates for a number of years[3], then a current account surplus will arise simply because of the increasing cumulative difference in the relative size of final demand in the two economies.[4] The second channel, the *price and cost competitiveness channel*, is rooted in wage and inflation developments brought about by labor market forces and, as in our model, wage bargaining mechanisms. As Southern European economics expand and

[1] A similar development took place in the New Member States affected by simultaneous credit bubbles and current account deficits.

[2] One of the key mechanisms for high multiplier effects is the *real interest rate channel* mentioned below.

[3] under the assumption of ceteris paribus, including constant import propensities

[4] In some countries, such as Spain and Ireland, the additional demand injection came about through a real estate bubble in which increased private sector borrowing drove up real estate prices and spurred construction activity. In other countries, government spending was too high relative to the external constraint (Greece). As Picek and Schröder (2017) show in a multiregional input-output framework, direct demand spillover effects, however, have been small, even if one accounts for multiplier effects and global value chains. While basic IO models cannot capture price competitiveness and monetary policy channels, they excel at simulating direct demand spillover effects through trade at a level of regional detail that DSGE models cannot provide.

manage to lower their unemployment rates following an initial demand impulse, wage demands of workers increase, ultimately resulting in higher prices via a Phillips curve. With trade added to the picture, the South loses relative cost and price competitiveness, and exports from the North now manage to capture an increasing market share in the South as long as demand traded costs is reasonably price-elastic. A large literature has debated cost competitiveness using unit labor cost developments among Euro Area countries, i.e. whether the the main causality goes from diverging wage levels (relative to labor productivity) to current account balances as claimed by Lapavitsas and Flassbeck (2013). Most participants in the debate favor a weak role for cost and price competitiveness as opposed to income effects (Gaulier and Vicard, 2012; Schröder, 2016; Storm and Naastepad, 2015; Gabrisch and Stähr, 2015). However, this part of the literature largely foregoes any explicit macroeconomic modeling, which makes it hard to distinguish the effects of the different channels and keep track off all their spillover effects on the various markets. One such channel is the *real interest rate channel* that stimulates foreign demand indirectly if a domestic fiscal expansion increases the area-wide inflation rate as long as the central bank targets the area-wide rate. Lower foreign inflation then decreases the local real interest rate which makes optimizing agents switch consumption to the present in a standard Euler equation consumption framework. In the DSGE literature, these three channels can typically be found in two-country models of the sort that we undertake in this paper. Among others, Blanchard et al. (2015) explicity attempt to model a core and periphery in the Euro Area, while Breuss and Rabitsch (2009), Andrés et al. (2006) and Pytlarczyk (2005) focus on the Euro Area and one of its member states (Austria, Spain, and Germany, respectively). Finally, an effect that is unique to three- or multi-country models is the exchange rate channel.[5] An expansion in the core lowers the exchange rate of the currency union from which the periphery may profit as it raises price competitiveness and therefore net exports towards third countries.

Wage dynamics play both an important causal and propagating role through several of these channels. Generally, a full macroeconomic model is preferable to disentangle the effect of several of these shocks. However, particularly in regard to the DSGE models, the literature is rather small because because wages are typically decentralized and privately efficient. Even worse, persistence in current account balances is hard to generate because of the general equilibrium structure of these models. The main purpose of the present paper is to analyze in greater detail than comparable DSGE studies studies the role that divergent wage dynamics have played for persistent current account imbalances. To this end, we extend the closed model framework of Schoder (2017a), who has presented a Dynamic Stochastic Disequilibrium model, to a two-country model of a currency union. The original model combines disequilibrium theory with inter-temporal optimization and rational expectations. The fact that agents optimize makes it immune to the Lucas critique that simpler stock-flow consistent models of the Post-Keynesian tradition with aggregate parameters are subject to. Likewise, in comparison to standard DSGE models, two particular advantages arise: Firstly, the rate of wage inflation is a policy variable subject to a collective bargaining process between firms' and workers' representatives rather than as an accommodating variable that gives rise to privately efficient wage contracts. Hence, the labor market does not clear in equilibrium and Keynesian unemployment prevails as labor is not employed optimally. Secondly, an uninsurable risk of permanent income loss is introduced to the household's problem which motivates the existence of precautionary savings and provides a mechanism by which consumption depends on income and

[5]Various extension and additional channels are possible. For instance, Poutineau and Vermandel (2015) include cross-border banking flows.

wealth even in equilibrium. Ultimately, this yields a Keynesian type of consumption function. With regard to the labor market, the model may be viewed as an attempt to understand policy propagation mechanisms if labor resources are permanently unter-utilized. While the model has several policy implications, one of its strengths is that labor productivity and the real wage move together.

The model is calibrated to typical specifications in the literature. Firstly, we use an symmetric calibration of the two economies to analyze separately an aysmmetric shock to wage bargaining, government spending, and total factor productivity as well as a common monetary policy shock. Impulse responses are provided for all of them for both the domestic and foreign economy. A comparison with a standard DSGE model is drawn, highlighting the distinct Keynesian features of the model. The results of the closed economy version carry over to the currency union version. In a second step, we calibrate the two economies symmetrically with the exception of one key difference. The domestic country runs on a corporatist wage formation regime, while the foreign country is subject to conflictive collective bargaining relations. A comparison of government spending shocks in the domestic and foreign economy as well as a common monetary policy shock reveals that the corporatist regime generally fares better. This is largely due to their superior external performance when faced with these shocks. Finally, we analyze the introduction of feedback from the trade balance to the wage formation process. In terms of recent policy discussions on current account imbalances, this could be viewed as an adjustment in the goals of the domestic social partners in the collective wage bargaining process to take into account the trade balance with the foreign country – and therefore policy in the monetary union to an extent. The introduction of this feedback stabilizes the system by dampening the impulse response functions in both countries and in both directions, negative and positive.

The remainder of the paper is structured in a straighforward way. In Section 2, we present the model mainly along the lines of the domestic economy. In Section 3, we present the impulse response function for the major shocks and model versions. Finally, Section 4 concludes.

2 The model

The two-country model presented here is an extension of the Dynamic Stochastic Dis-Equilibrium model introduced by Schoder (2017b). To keep the model tractable, we model the international linkages as in Pytlarczyk (2005) and Breuss and Rabitsch (2009). Both economies are populated by *active and inactive households*, *intermediate goods firms* (producing heterogeneous consumption and investment goods), *final consumption and investment goods firms* (bundling intermediate goods in homogeneous final goods), *retailers* (combining domestic and foreign goods into consumption and investment aggregates), a fiscal policy authority, as well as workers' and firms' representatives in the wage bargaining process. The monetary authority of the monetary union controls the common interest rate.

Details on the underlying DSDE model can be found in Schoder (2017b). The open economy aspects are further discussed in Pytlarczyk (2005) and Breuss and Rabitsch (2009). In this section we restrain ourselves to stating the model equations and providing the intuition. Since we model the foreign country symmetric to the domestic country, we only present the equations for the domestic country. Note that an asterisk indicates a variable of the foreign country.

2.1 Households

As in Schoder (2017b), households are born in generations of constant size. Each newborn household is part of the labor force–a state we refer to as *active*. Yet, the active household faces a constant per-period risk of becoming *inactive* losing all future labor and capital income. There is no insurance market for this risk. Once the household is inactive it cannot return to the active state. It faces the risk of death with a constant probability. While active, the rational household will accumulate precautionary savings as a buffer for the time when inactive.

We make three assumptions which allow us to derive closed-form relations of aggregated variables despite partial wealth heterogeneity across households: First, inactive households have access to a Blanchard (1985) insurance mechanism that ensures that there are no accidental bequests when dying. Bequests are transfered to inactive households that are still alive. Second, active households are subject to a transfer that enures that newborn households have the same wealth-income ratio as non-newborn active households. Third, we assume log-utility in consumption.

Under these assumptions, we can obtain the aggregated budget constraint of the inactive households as

$$\tilde{C}_{i,t} + \tilde{B}_{i,t} = \frac{1}{\Gamma}\frac{R_{t-1}}{\Pi_{C,t}}\left(\tilde{B}_{i,t-1} + U\tilde{B}_{a,t-1}\right) \tag{1}$$

where the variables $\tilde{C}_{i,t}$, $\tilde{B}_{i,t}$, R_t, $\Pi_{C,t}$, and $\tilde{B}_{i,t}$ denote consumption of the inactive households, end-of-period wealth of the inactive households, the gross interest rate, the inflation rate of consumer prices, and the wealth of active households, respectively. Γ is the determinstic growth rate of labor embodied productivity. Note that the tilde indicates variables that are detrended by deterministic growth. The budget constraint in equation (1) equates uses and sources of funds. The only non-standard feature is that sources include the previous period wealth of active households. This is because from period $t-1$ to t a share of U of active households become inactive and bring their wealth over.

The inactive household's first order conditions (FOCs) imply that its period t consumption will be proportional to its beginning-of-period wealth. Since the proportionality factor κ is constant we can easily aggregate over all inactive households including newly inactive households to obtain

$$\tilde{C}_{i,t} = \kappa\frac{1}{\Gamma}\frac{R_{t-1}}{\Pi_{C,t}}\left(\tilde{B}_{i,t-1} + U\tilde{B}_{a,t-1}\right) \tag{2}$$

where $\kappa = (1-\beta(1-D))$ with β and D denoting the discount factor and the per-period risk of death, respectively.

Equivalently, the active households budget constraints can be aggregated to yield

$$\tilde{C}_{a,t} + \tilde{B}_{a,t} = \tilde{Z}_t + (1-U)\frac{1}{\Gamma}\frac{R_{t-1}}{\Pi_{C,t}}\tilde{B}_{a,t-1} \tag{3}$$

where $\tilde{C}_{a,t}$ is consumption of active households and

$$\tilde{Z}_t = \tilde{\omega}_t L_t + \tilde{P}_t - p_{d,t}\tilde{T}_t \tag{4}$$

is the active households' real net income. $\tilde{\omega}_t$, L_t, $\tilde{P}_t$, $p_{d,t}$, and $\tilde{T}_t$ denote the real wage in terms of consumption goods, labor input, real profits in terms of consumption goods, prices of domestic

goods normalized by consumer prices, and real lump-sum taxes in terms of consumption goods. Note that $L_t = (1 - u_t)N_t$, which is implied by the definition of the unemployment rate

$$1 - u_t = \frac{L_t}{N_t}, \tag{5}$$

where N_t is labor supply and u_t is the unemployment rate.

The aggregated FOCs of the active households states that consumption should be chosen such that the marginal utility in t is equal to the expected marginal utility in $t+1$. Since, the currently active household may be newly inactive in the next period, the expected marginal utility also depends on the households consumption choice next period in case it became inactive. Hence, it internalizes the optimal behavior of the inactive household. We get

$$\frac{\theta}{\tilde{C}_{a,t}} = \beta(1-U)\frac{1}{\Gamma}\mathrm{E}_t\frac{R_t}{\Pi_{C,t+1}}\frac{\theta}{\tilde{C}_{a,t+1}} + \beta U\frac{1}{\kappa\tilde{B}_{a,t}} \tag{6}$$

where θ is a consumption utility scaling parameter. Note that this equation collapses to the standard Euler equation when $U = 0$.

Overall consumption is

$$\tilde{C}_t = \tilde{C}_{a,t} + \tilde{C}_{i,t} \tag{7}$$

Aggregation of the FOC w.r.t. labor supply leads to

$$\psi U^{1+\eta} N_t^{\eta} = \frac{\theta}{\tilde{C}_{a,t}}\tilde{\omega}_t(1 - u_t). \tag{8}$$

where ψ and η are a labor disutility scaling parameter and the inverse of the Frisch elasticity, respectively.

2.2 Firms

Retail firms. In the aggregate, households and firms purchase consumption bundles, C_t, and investment bundles, I_t, respectively. These bundles are generated by perfectly competitive representative consumption good retailers and investment good retailers, respectively. They combine homogenous domestic final goods and foreign final goods using a Constant Elasticity of Substitution (CES) aggregator. The consumption retailers problem reads

$$\begin{aligned} &\max_{C_{d,t}, C_{f,t}} P_{C,t}C_t - (P_{d,t}C_{d,t} + P_{f,t}C_{f,t}) \\ &s.t. \quad C_t = \left(\gamma_c{}^{\frac{1}{\epsilon_c}} C_{d,t}{}^{\frac{\epsilon_c - 1}{\epsilon_c}} + (1-\gamma_c)^{\frac{1}{\epsilon_c}} C_{f,t}{}^{\frac{\epsilon_c - 1}{\epsilon_c}}\right)^{\frac{\epsilon_c}{\epsilon_c - 1}}, \end{aligned}$$

where $C_{d,t}$ and $C_{f,t}$ are the domestic and foreign final consumption good inputs, respectively, $P_{d,t}$ and $P_{f,t}$ are the prices of these goods, $P_{C,t}$ is the price of the final consumption bundle, γ_c is the share of domestic consumption good inputs when domestic and foreign input prices are equal, and $\epsilon_c > 1$ is the elasticity of substitution. Note that the government purchases domestic consumption goods straight from the final consumption goods firm and not from the retailer. The FOCs are

$$\tilde{C}_{d,t} = \gamma_c p_{d,t}{}^{-\epsilon_c}\tilde{C}_t \tag{9}$$

and

$$\tilde{C}_{f,t} = (1-\gamma_c){p_{f,t}}^{-\epsilon_c}\tilde{C}_t. \tag{10}$$

With the optimal choice of $C_{d,t}$ and $C_{f,t}$ at a given $P_{d,t}$ and $P_{f,t}$, one can compute the implied aggregate price index of the consumption bundle as

$$1 = \left(\gamma_c {p_{d,t}}^{1-\epsilon_c} + (1-\gamma_c){p_{f,t}}^{1-\epsilon_c}\right)^{\frac{1}{1-\epsilon_c}} \tag{11}$$

The investment retailers problem is symmetric to the consumer retailers problem and yields the FOCs,

$$\tilde{I}_{d,t} = \gamma_i \left(\frac{p_{d,t}}{p_{I,t}}\right)^{-\epsilon_i} \tilde{I}_t \tag{12}$$

and

$$\tilde{I}_{f,t} = (1-\gamma_i) \left(\frac{p_{f,t}}{p_{I,t}}\right)^{-\epsilon_i} \tilde{I}_t. \tag{13}$$

With the optimal choice of $I_{d,t}$ and $I_{f,t}$ at a given $P_{d,t}$ and $P_{f,t}$, one can compute the implied aggregate price index of the consumption bundle as

$$p_{I,t} = \left(\gamma_i {p_{d,t}}^{1-\epsilon_i} + (1-\gamma_i){p_{f,t}}^{1-\epsilon_i}\right)^{\frac{1}{1-\epsilon_i}}. \tag{14}$$

Final good firms. There are two symmetric representative perfectly competitive final goods firms: one for consumption goods and one for investment goods. The final goods firms purchase only domestic differentiated intermediate goods and bundle them into a homogeneous domestic consumption good and a homogenous domestic investment good, respectively, sold to foreign and domestic retailers. Taking as given price $p_{i,t}$, the final consumption good firm's demand for the intermediate good $y_{C,i,t}$ supplied by intermediate good firm i can be obtained from the following cost minimization problem:

$$\begin{aligned} &\max_{y_{C,i,t}} P_{d,t}(C_{d,t} + C^*_{d,t} + G_t + A_{k,t} + A_{p,t}) - \int_0^1 p_{i,t} y_{C,i,t} di \\ s.t.\quad & C_{d,t} + C^*_{d,t} + G_t + A_{k,t} + A_{p,t} = \int_0^1 \left({y_{C,i,t}}^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}, \end{aligned}$$

where G_t is government spending, $A_{k,t}$ and $A_{p,t}$ are capital and price adjustment costs, respectively, and $\epsilon > 1$ is the elasticity of substitution. Note that the asterisk denotes the foreign country. Noting that the Lagrangian multiplier of the constraint is equal to the aggregate price index, $P_{C,t}$, one can show the FOC to read

$$y_{C,i,t} = \left(\frac{p_{i,t}}{P_{d,t}}\right)^{-\epsilon} (C_{d,t} + C^*_{d,t} + G_{d,t} + A_{k,t} + A_{p,t}).$$

Equivalently, taking as given price $p_{i,t}$, the final investment good firm's demand for the intermediate good $y_{I,i,t}$ supplied by intermediate good firm i can be obtained as

$$y_{I,i,t} = \left(\frac{p_{i,t}}{P_{d,t}}\right)^{-\epsilon} (I_{d,t} + I^*_{f,t}).$$

Intermediate good firms. Taking as given total output Y_t, the overall price level $P_{C,t}$, and the wage rate ω_t as well as the law of motion of capital, the production function, the demand function for intermediate goods, and the requirement to maintain a debt-capital ratio λ, the firm i chooses $\{p_{i,t}, l_{i,t}, i_{i,t}, k_{i,t}, d_{i,t}\}_{t=0}^{\infty}$ to maximize discounted inter-temporal distributed profits. Dropping the firm index for convenience and evaluating at period $t = 0$, the optimization problem reads

$$\begin{aligned}
\max_{\{p_t, l_t, i_t, k_t, d_t\}_{t=0}^{\infty}} \; & \mathrm{E}_0 \sum_{t=0}^{\infty} \frac{P_{C,0}}{P_{C,t}} \Lambda_{0,t} \begin{bmatrix} p_t y_{C,t} + p_t y_{I,t} - P_{C,t}\omega_t l_t - P_{I,t} i_t - P_{d,t} A_{k,t} - P_{d,t} A_{p,t} + \\ + P_{C,t} d_t - R_{t-1} P_{C,t-1} d_{t-1} \end{bmatrix} \\
s.t. \quad & k_t = i_t + (1-\delta) k_{t-1} \\
& y_{C,t} + y_{I,t} = V_{A,t} \left(\Gamma k_{t-1}\right)^{\alpha} \left(\Gamma^t l_t\right)^{1-\alpha} \\
& y_{C,t} = \left(\frac{p_t}{P_{d,t}}\right)^{-\epsilon} \left(C_{d,t} + C^*_{d,t} + G_{d,t} + A_{k,t} + A_{p,t}\right) \\
& y_{I,t} = \left(\frac{p_t}{P_{d,t}}\right)^{-\epsilon} \left(I_{d,t} + I^*_{d,t}\right) \\
& A_{k,t} = \frac{\tau_i}{2} \left(\frac{i_t}{\Gamma k_{t-1}} - \left(1 - (1-\delta)\frac{1}{\Gamma}\right)\right)^2 k_{t-1} \\
& A_{p,t} = \frac{\tau_p}{2} \Gamma^t \left(\frac{p_t}{P_{C,t-1}} - \Pi\right)^2 \\
& d_t = \lambda q_t k_t
\end{aligned}$$

where $i_{i,t}$, $k_{i,t}$, $d_{i,t}$, $V_{A,t}$, and q_t are investment, the capital stock, outstanding bonds, total factor productivity, and the price of capital, respectively. τ_i, δ, τ_p, and α denote the capital adjustment costs scaling parameter, the rate of capital depreciation, the price adjustment costs scaling parameter, and the capital elasticity of production. $\Lambda_{t,t+j}$ is the stochastic discount factor which expresses the value of a unit real profit in time $t+j$ in terms of the value of a unit real profit in time t.

The FOC w.r.t. d_t implies that the financial structure of the firm is irrelevant from the household's perspective.

Regarding the price decision, note that all firms charge the same price, $p_t = P_{d,t}$, independent on weather they are sold to the final consumption good or final investment good firm. Hence $y_{C,t} + y_{I,t} = Y_t$ with a mass one of firms. The FOC w.r.t. p_t then implies

$$\left((\epsilon - 1) - \epsilon \frac{\varphi_t}{p_{d,t}}\right) \tilde{Y}_t + \tau_p \left(\Pi_{d,t} - \Pi_C\right) \Pi_{d,t} - \mathrm{E}_t \Lambda_{t,t+1} \tau_p \Gamma \left(\Pi_{d,t+1} - \Pi_C\right) \frac{{\Pi_{d,t+1}}^2}{\Pi_{C,t+1}} = 0 \tag{15}$$

where φ_t is the lagrangian multiplier of the production function constraint and has the interpretation of real marginal costs and where

$$\Lambda_{t-1,t} = \left(\frac{R_{t-1}}{\Pi_{C,t}}\right)^{-1} \tag{16}$$

as well as

$$\Pi_{d,t} = \frac{p_{d,t}}{p_{d,t-1}} \Pi_{C,t}. \tag{17}$$

The FOC w.r.t. l_t, i_t, and k_t imply

$$\varphi_t = \tilde{\omega}_t \frac{1}{1-\alpha} \left(\frac{1}{V_{A,t}} \right)^{\frac{1}{1-\alpha}} \left(\frac{\tilde{Y}_t}{\tilde{K}_{t-1}} \right)^{\frac{\alpha}{1-\alpha}}, \tag{18}$$

$$q_t = p_{I,t} + p_{d,t}\tau_i \frac{1}{\Gamma} \left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} - \left(1 - (1-\delta)\frac{1}{\Gamma} \right) \right), \tag{19}$$

and

$$q_t = \mathrm{E}_t \Lambda_{t,t+1} \begin{bmatrix} p_{d,t+1}\tau_i \left(\frac{\tilde{I}_{t+1}}{\tilde{K}_t} - \left(1 - (1-\delta)\frac{1}{\Gamma} \right) \right) \frac{\tilde{I}_{t+1}}{\tilde{K}_t} - \\ -p_{d,t+1}\frac{\tau_i}{2} \left(\frac{\tilde{I}_{t+1}}{\tilde{K}_t} - \left(1 - (1-\delta)\frac{1}{\Gamma} \right) \right)^2 + \\ +\varphi_{t+1}\alpha \frac{\tilde{Y}_{t+1}}{\tilde{K}_t} + q_{t+1}(1-\delta) \end{bmatrix}, \tag{20}$$

respectively. Aggregating the law of motion of the capital stock leads to

$$\tilde{K}_t = \tilde{I}_t + (1-\delta)\frac{1}{\Gamma}\tilde{K}_{t-1} \tag{21}$$

The aggregated production function reads

$$\tilde{Y}_t = V_{A,t}\tilde{K}_{t-1}^{\alpha} L_t^{1-\alpha}. \tag{22}$$

Recalling that firms maintain a debt-capital ratio of λ, the aggregated detrended real distributed profits are

$$\begin{aligned} \tilde{\Pi}_{d,t} = p_{d,t}\tilde{Y}_t - \tilde{\omega}_t L_t - (1-\lambda)p_{I,t}\tilde{I}_t - p_{d,t}\frac{\tau_i}{2}\frac{1}{\Gamma} \left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} - \left(1 - (1-\delta)\frac{1}{\Gamma} \right) \right)^2 \tilde{K}_{t-1} - \\ - p_{d,t}\frac{\tau_p}{2} \left(\Pi_{C,t} - \Pi_C \right)^2. \end{aligned} \tag{23}$$

The growth rate of the real wage is linked to wage and price inflation according to

$$\frac{\tilde{\omega}_t}{\tilde{\omega}_{t-1}} - 1 = \Pi_{w,t} - \Pi_{C,t}. \tag{24}$$

2.3 The labor market

We take the rate of wage inflation as subject to a bargaining process between a workers' and a firms' representative. We assume that the steady-state real wage $\tilde{\omega}(\Pi^{w,t})$ as the worker's return and the steady-state profit rate, $r(\Pi^{w,t})$, as the firm's return. Due to the presence of price adjustment costs, the former can be shown to increase and the latter to decrease in the rate of wage inflation. Hence, we suggest that the bargaining parties are concerned with the long-run implications of the bargaining. By assuming that the state of the labor market affects the relative bargaining power, however, the rate of wage inflation will be cyclical. The FOC of the bargaining game determines the rate of nominal wage inflation, $\Pi_{w,t}$, and reads

$$1 = (1 - 1/\nu_t)\frac{\tilde{\omega}(\Pi_{w,t})}{r(\Pi_{w,t})}\frac{r'(\Pi_{w,t})}{\tilde{\omega}'(\Pi_{w,t})}. \tag{25}$$

where

$$\frac{\nu_t}{\nu} = \left(\frac{1-u_t}{1-u}\right)^{\phi_u} V_{\nu,t} \tag{26}$$

Note that there is not feedback of the labor market to wage formation if $\phi_u = 0$. In this case, the rate of wage inflation is constant.

2.4 Fiscal policy

We assume the government budget to be balanced at all times, i.e.

$$\tilde{T}_t = \tilde{G} \tag{27}$$

$$\frac{\tilde{G}_t}{\tilde{G}} = V_{G,t} \tag{28}$$

2.5 Goods market clearing

As can easily be verified, aggregating over all budget constraints leads to the macro-economic balance condition,

$$\begin{aligned}\tilde{Y}_t = {} & \tilde{C}_{d,t} + \tilde{C}^*_{d,t} + \tilde{I}_{d,t} + \tilde{I}^*_{d,t} + \tilde{G} + \\ & + \frac{\tau_i}{2}\frac{1}{\Gamma}\left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)^2 \tilde{K}_{t-1} + \frac{\tau_p}{2}\left(\Pi_{C,t} - \Pi_C\right)^2\end{aligned} \tag{29}$$

2.6 Exogenous processes

The fiscal policy shock, monetary policy shock, total factor productivity shock, and worker bargaining power shock are assumed to evolve according to

$$V_{G,t} = {V_{G,t-1}}^{\rho_G} \exp \varepsilon_{G,t}, \tag{30}$$

$$V_{R,t} = {V_{R,t-1}}^{\rho_R} \exp \varepsilon_{R,t}, \tag{31}$$

$$V_{A,t} = {V_{A,t-1}}^{\rho_A} \exp \varepsilon_{A,t}, \tag{32}$$

$$V_{\nu,t} = {V_{\nu,t-1}}^{\rho_\nu} \exp \varepsilon_{\nu,t}, \tag{33}$$

where $\varepsilon_{G,t} \sim \mathcal{N}(0,1)$, $\varepsilon_{R,t} \sim \mathcal{N}(0,1)$, $\varepsilon_{A,t} \sim \mathcal{N}(0,1)$, and $\varepsilon_{\nu,t} \sim \mathcal{N}(0,1)$ are exogenous innovations.

2.7 International linkages

The final goods firms sell their products domestically and abroad. Under a common currency and without costs of trade,

$$P_{d,t} = P^*_{d,t}$$
$$P_{f,t} = P^*_{f,t}.$$

That is, a BMW sold in Germany needs to have the same price as a BMW sold in France. Equivalently, a Renault sold in Germany needs to have the same price as a Renault sold in France. Note however that $p_{d,t} \neq p^*_{d,t}$ as $P_{C,t} \neq P^*_{C,t}$. Defining the real exchange rate as $E_t = P^*_{C,t}/P_{C,t}$, we have

$$p_{d,t} = p^*_{d,t} E_t \tag{34}$$
$$p_{f,t} = p^*_{f,t} E_t. \tag{35}$$

Arbitrage between bonds implies a restriction on the real exchage rate (see Breuss and Rabitsch 2008, footnote 8):

$$\frac{E_{t+1}}{E_t} = \frac{\Lambda^*_{t,t+1}/\beta^*}{\Lambda_{t,t+1}/\beta}. \tag{36}$$

We assume the common monetary authority to set the interest rate according to

$$\frac{R_t}{R} = \left(\frac{\Pi_{C,t}}{\Pi_C}\right)^{\phi_{r\pi}} V_{R,t} \tag{37}$$

3 Impulse response analysis

In the present section, we provide the impulse response analysis of four of the macroeconomic shocks in our *baseline* two-country DSDE model: A domestic productivity shock, a domestic fiscal policy shock, a common monetary policy shock, and, most importantly, a domestic wage bargaining shock. Whenever possible, we compare our disequilibrium version to a more standard DSGE version of the model to highlight the effects of the differences in the two model economies.

Moreover, we analyze modifications of the wage bargaining process in more detail. We may assume two distinct bargaining regimes for the two countries. Intuitively, unions and employers either work together (corporatist) or fight each other (conflicting). Monetary and fiscal policies affect the two countries to a varying degree and in different ways when these particular regimes dominate the wage setting process. Finally, we ask what would happen if the wage bargaining process took into account the current trade balance, i.e. the macroeconomic leeway (or restriction) that the external constraint provides serves as a feedback to the bargaining process. Regarding political relevance, the latter scenario particularly applies to calls for current account surplus countries within the Euro Area to inflate their economy.

In Figure 1, a shock to domestic total factor productivity of 1% of its steady state value is applied. In a standard DSGE model (dashed line), higher labor productivity means an increase in the marginal product of labor in the domestic economy. Without sticky wages, both the nominal and the real wage adjust instantaneously, so that full employment is guaranteed at all times. As the marginal product of labor has increased, the same output can be produced with less required labor

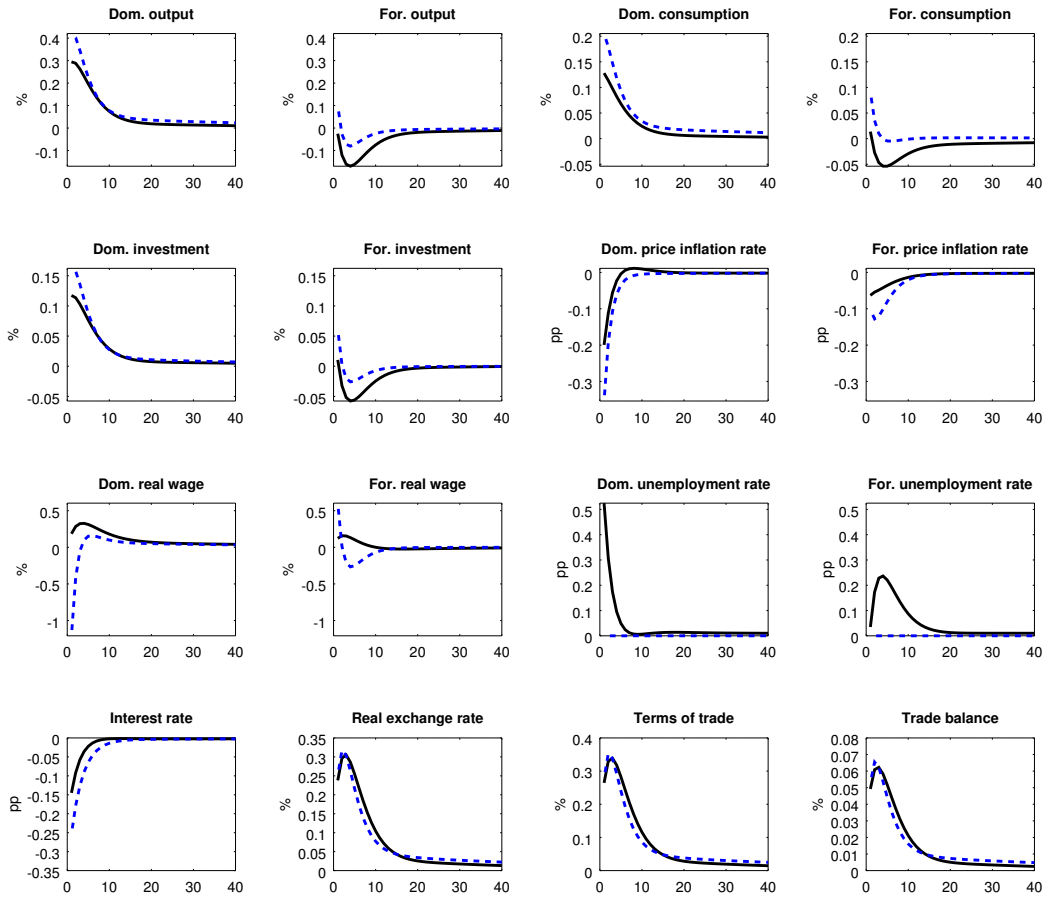

Figure 1: Macroeconomic responses to a productivity shock in the domestic country as predicted by the baseline DSDE model (solid line) and the corresponding DSGE model (dashed line).

input. Therefore, the domestic real wage falls by more than 1% initially to keep the equilibrium in the labor market before converging back to the steady state value after a few periods. Indeed, it is here in the labor market that we see the biggest difference of the DSDE model to a comparable DSGE set-up. Instead of a fall in the real wage at full employment, domestic unemployment rises by more than .5 percentage points given the parameter calibrations. At the same time, the real wage increases slightly because wage inflation falls less than price inflation, lowering the mark-up temporarily.

Generally, however, a productivity shock is favorable in both the DSGE and the DSDE model for the domestic economy as a whole. A higher marginal product of labor means that potential output rises and a higher marginal product of capital means that firms demand more capital. Since capital does not adjust instantaneously, investment is demanded and builds up the higher capital stock over the course of several periods. During this slow adjustment, multiplier effects are exerted and

lift up consumption and output. The effects are a bit weaker in the DSDE model than in the DSGE model because part of the potential additional output cannot be realized due to the increase in the unemployment rate.
The foreign country suffers from the domestic productivity increase in the DSDE model. Since prices fall much more in the domestic economy than in the foreign one, the terms of trade worsen for the foreign economy, and the real exchange rate increases. Consequently, the trade balance worsens as well form the point of view of the foreign economy. Output, consumption and investment all fall. This is somewhat different in the DSGE model, where two countervailing forces interact. Therein, lower (domestic and foreign) prices pull up foreign real consumption, investment and output. However, the negative competitiveness effects dominate after period 1 through the terms of trade. Foreign investment and output fall below the steady state level. In the DSDE model, the additional negative effect from the increase in unemployment shifts down the adjustment trajectories in output, investment and consumption.

In Figure 2, a 1% shock to domestic fiscal policy is simulated. While we assume a balanced budget, the shock does have a positive multiplier effect on domestic output and unemployment falls compared to its steady state level. As price inflation rises, the common central bank also raises the area-wide interest rate. While this and other simultaneous effects do not manage to drive output effects to negative territory, they do so for investment and consumption. The terms of trade, the real exchange rate and the trade balance all deteriorate from the point of view of the domestic country. The foreign economy of the DSDE model, however, sees an expansion that it would see to such an extent in the DSGE model. Presumably, the stronger expansion rests on a combination of the the wealth effect of an increase in the real interest rate and the employment effects of the spillovers from the domestic economy. Foreign output, investment and consumption all increase

In Figure 3, a common monetary policy shock of 1% (higher interest rates) meets the two (symmetrically calibrated) economies. Unsurprisingly, the effects are identical on both economies. This leaves the trade balance, the terms of trade and the real exchange rate constant (see the scale). The difference between the DSGE and the DSDE model is quite noteworty. Across the board, a negative wealth effect is present in the DSDE model. It lowers investment, consumption and output in both the domestic and foreign economy temporarily. While similar-looking short-term dynamics happen in the DSGE model for other reasons (intertemporal consumption smoothing that makes households move their consumption from the present to the future), the wealth effect in the disequilibrium model has permanent effects and brings about a new set of steady state values for a few key variables. It occurs because the central bank feels obliged to keep the real interest rate at a permanently higher level due to a permanently higher price inflation rate. The latter arises due to a lower unemployment level in the new steady state that increases the bargaining power of the union in the collective bargaining process. While output remains the same in the new steady state, the shares of consumption and investment in output have shifted: Real consumption is permanently elevated at over 0.2%, and investment permanently subdued at around -0.2% from the original steady state levels. Note the particular trajectory of the the unemployment rate: After the initial increase in unemployment that is stark with almost three percentage points, a new steady state is reached that features an almost 1% lower unemployment rate than in the original steady state. Since the model is classical and not Keynesian in the model, this lower unemployment rate must coincide with a new lower steady state value of the real wage (around -1%) when output has converged back to the old steady state.

In Figure 4, a 1% wage bargaining shock is applied to the domestic economy. Since collective

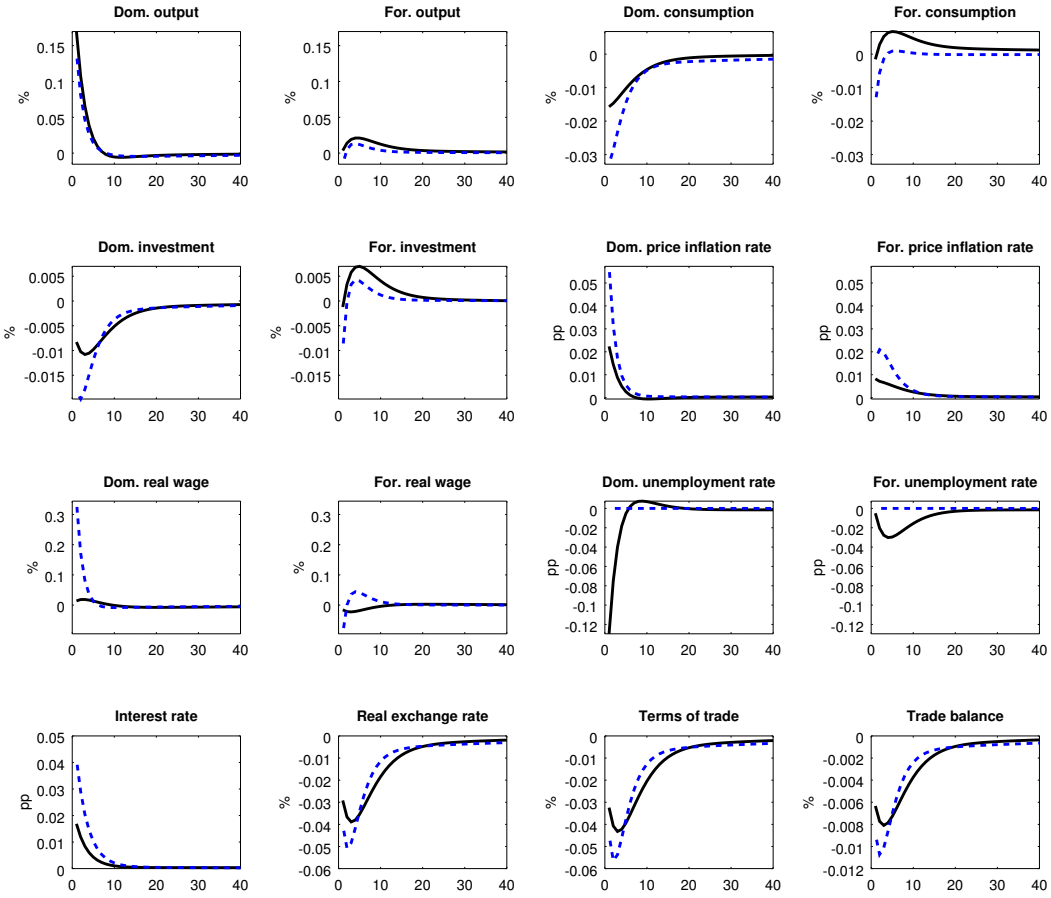

Figure 2: Macroeconomic responses to a fiscal policy shock in the domestic country as predicted by the baseline DSDE model (solid line) and the corresponding DSGE model (dashed line).

bargaining is unique to the DSDE model, there is no reference DSGE version. The effects are largely what one would expect intuitively given that the model. The domestic real wage increases because wage inflation rises more than price inflation. Because price inflation in the domestic economy increases more than in the foreign economy (which is stimulated through increased bilateral exports to the domestic economy), the terms of trade improve for the foreign economy, resulting in a better trade balance for the foreign economy. As both economies are also profit-led, the domestic economy temporarily loses output, consumption and investment. Domestic unemployment rises. The effects are reversed for the foreign economy. It gains output, consumption, investment, and experiences a fall in the unemployment rate.

In Figures 5 and 6, we assume that the bargaining regimes in the two countries are distinct. The domestic economy adheres to a corporatist bargaining regime, while the foreign economy follows a conflictive bargaining regime. In the model, the corporatist country has a higher price

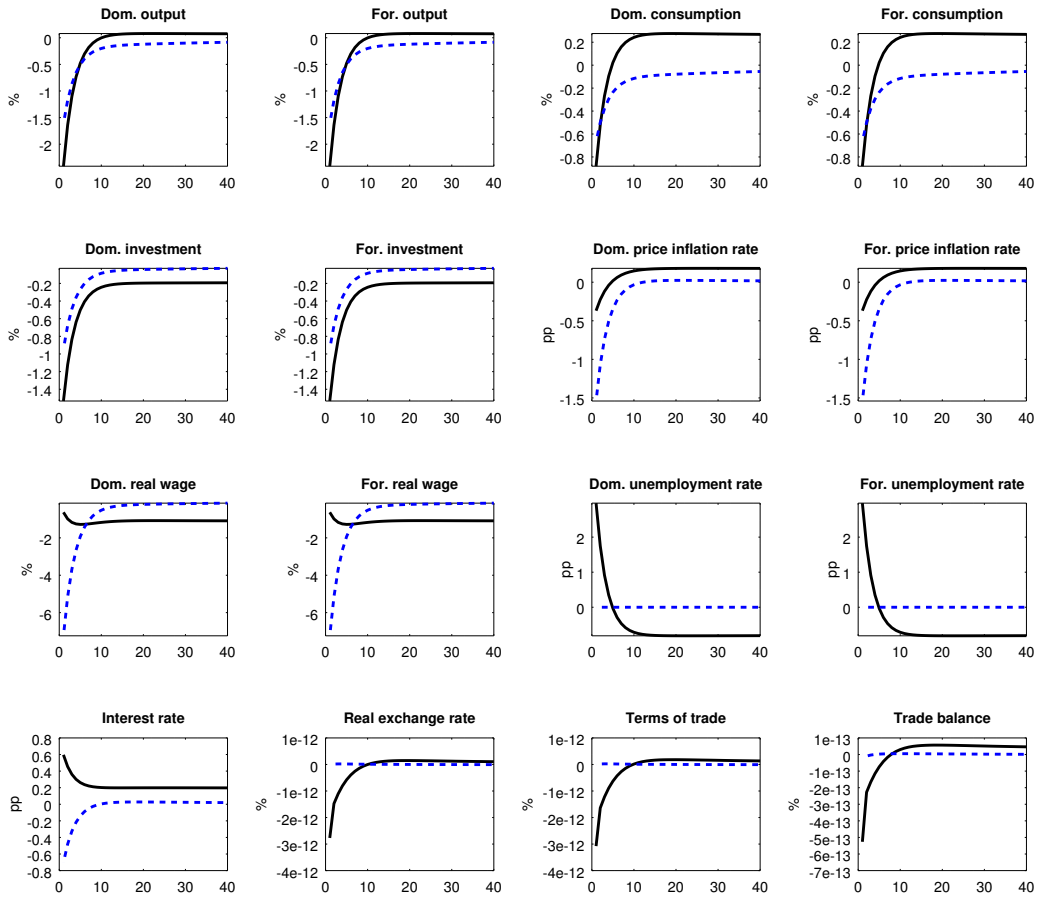

Figure 3: Macroeconomic responses to a monetary policy shock as predicted by the baseline DSDE model (solid line) and the corresponding DSGE model (dashed line).

adjustment cost, which is a simple way to depict the two regimes. The results in Figure 5 are based on a government spending shock in the corporatist domestic economy, whereas Figure 6 discusses the same shock in the the conflictive foreign economy. As before, both economies are calibrated equally otherwise. The conclusion can be summarized as follows: Comparing the overall own-economy gains of an identical government spending shock, the corporatist country wins over the conflictive country because its external performance is superior. In both figures, the dashed line is is the specification of the scenario, whereas the solid line is the baseline scenario as a reference, where both countries are symmetric. Generally, the corporatist domestic economy performs slightly better than the baseline specification while the conflictive one performs slightly worse, for example in terms of output and unemployment. The difference is particularly clear in terms of the external performance. Comparing the two dashed lines across the two figures, the terms of trade worsen by

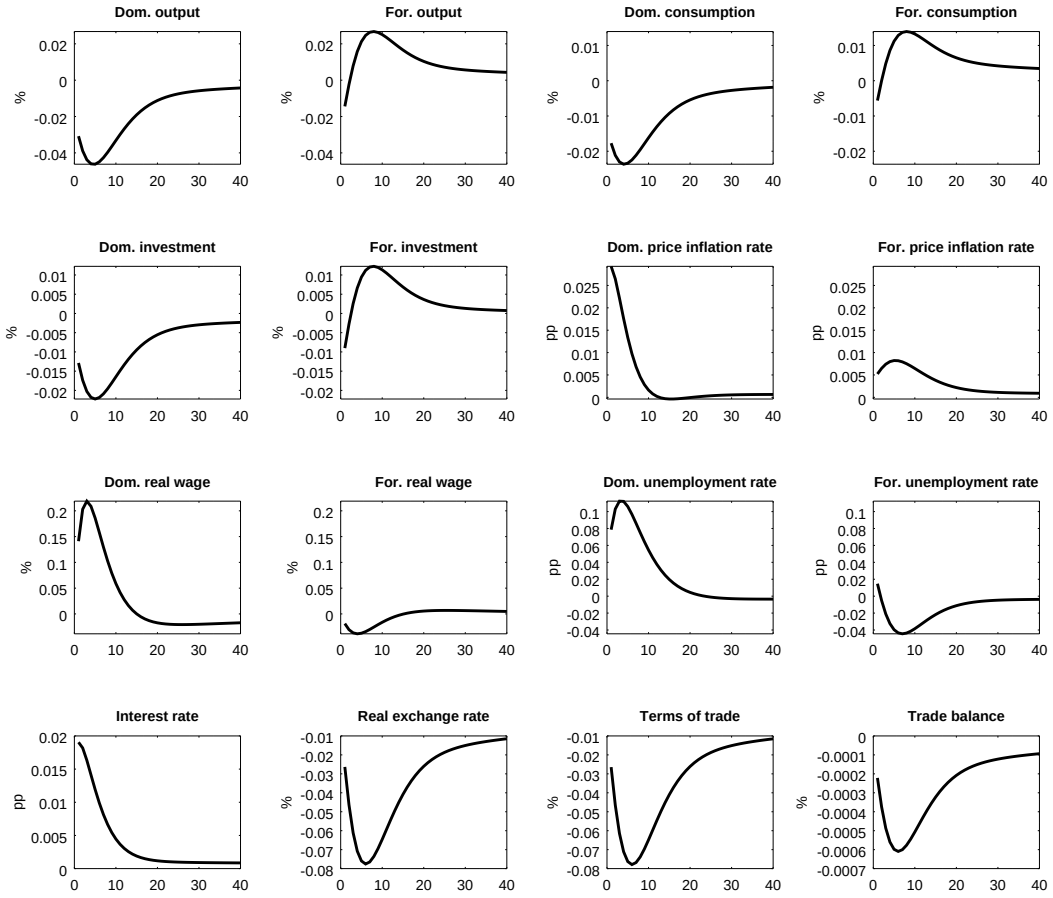

Figure 4: Macroeconomic responses to a wage bargaining power shock as predicted by the baseline DSDE model.

only .3% as a minimum in the corporatist regime, but by almost .6% in the conflictive regime.[6] As a result, the trade balance worsen by around .01% in the conflictive foreign country, but only by around .5% in the corporatist domestic country. One noteworthy difference arises in the behavior of the real wage. In the conflictive country, a government spending shock induces double the maximum rise in the foreign real wage as compared to the baseline model. If the shock hits the domestic economy, however, the domestic real wage remains suppressed and actually falls.

In Figure 7, a common monetary policy of 1% shock affects the two countries differently when the domestic country is coporatist and the foreign country conflictive. Domestic output, investment, consumption and employment remain permanently above the baseline scenario, while their foreign equivalents remains below. The trade balance changes temporarily in favor of the domestic of the domestic economy. The real wage in the two economies diverges in the long run, rising in the

[6]The trade balance is always depicted from the point of view of the domestic country.

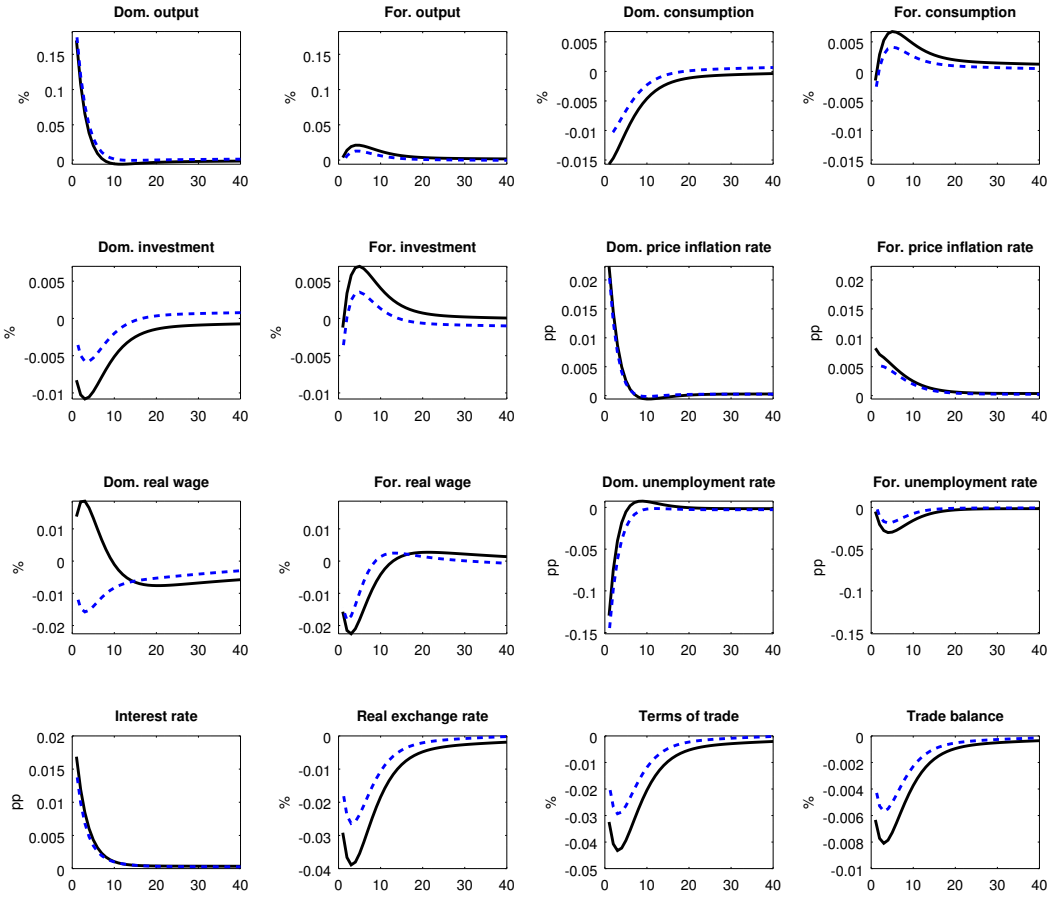

Figure 5: Macroeconomic responses to a government spending shock in the domestic country as predicted by the baseline specification (solid line) and a conflictive foreign country/corporatist domestic country specficition (dashed line).

domestic one and falling in the foreign one, while the price inflation rate converges back to the same level after an initial opposing reaction. Compared to the fiscal policy shocks in the previous two figures, the foreign economy fares even worse when faced with a monetary policy shock.

In Figure 8, we introduce a feedback of the trade balance on wage bargaining power. The idea is that enough political pressure is applied on the domestic country so that the collective bargaining wage formation process (presumably among social partners) begins to take into account the external balance in their decision-making. In case of a postive trade balance, the wage bargaining power of unions will therefore be weaker, and in case of a negative trade balance, the power of employers will be weaker. The figure compares the baseline model (solid) to the model with trade balance feedback on the bargaining process (dashed) when a bargaining shock hits the domestic economy. Given the parameter calibration, the real exchange rate, terms of trade and the trade balance deviations are

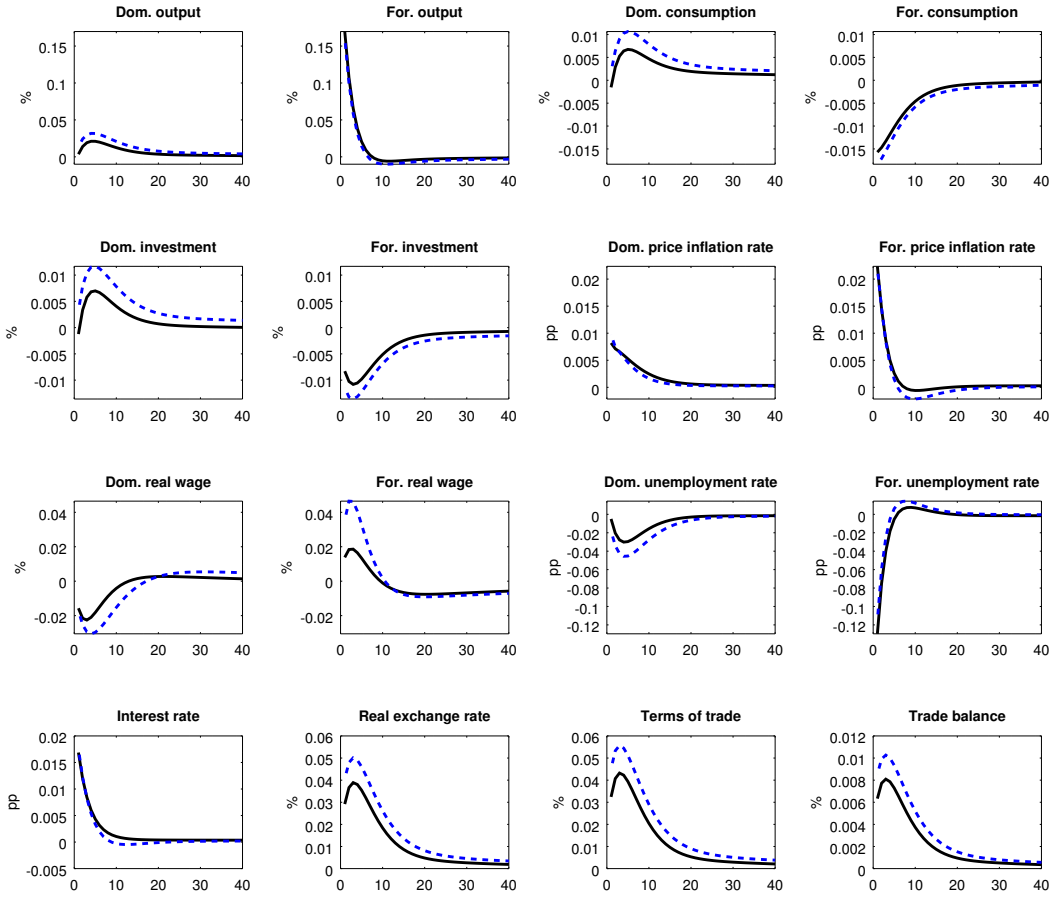

Figure 6: Macroeconomic responses to a government spending shock in the foreign country as predicted by the baseline specification (solid line) and a conflictive foreign country/corporatist domestic country specficition (dashed line).

halved. The domestic output, consumption and investment fall is damped. Domestic price inflation barely changes, but both the real wage and unemployment increase by less. The downside of the domestic feedback effect arises in the foreign country. The upswing in the foreign economy strongly damped. However, this contributes to the overall stability of the system. Finally, in Figures 9 and 10 the same trade balance feedback effect is presented for a domestic productivity shock and a government spending shock in the domestic economy. While the detailed interpretation is left for the reader, we merely note that the stabilizing properties of the feedback can be observed for those two shocks as well, perhaps with the exception of the the qualitatively different paths for the real wage.

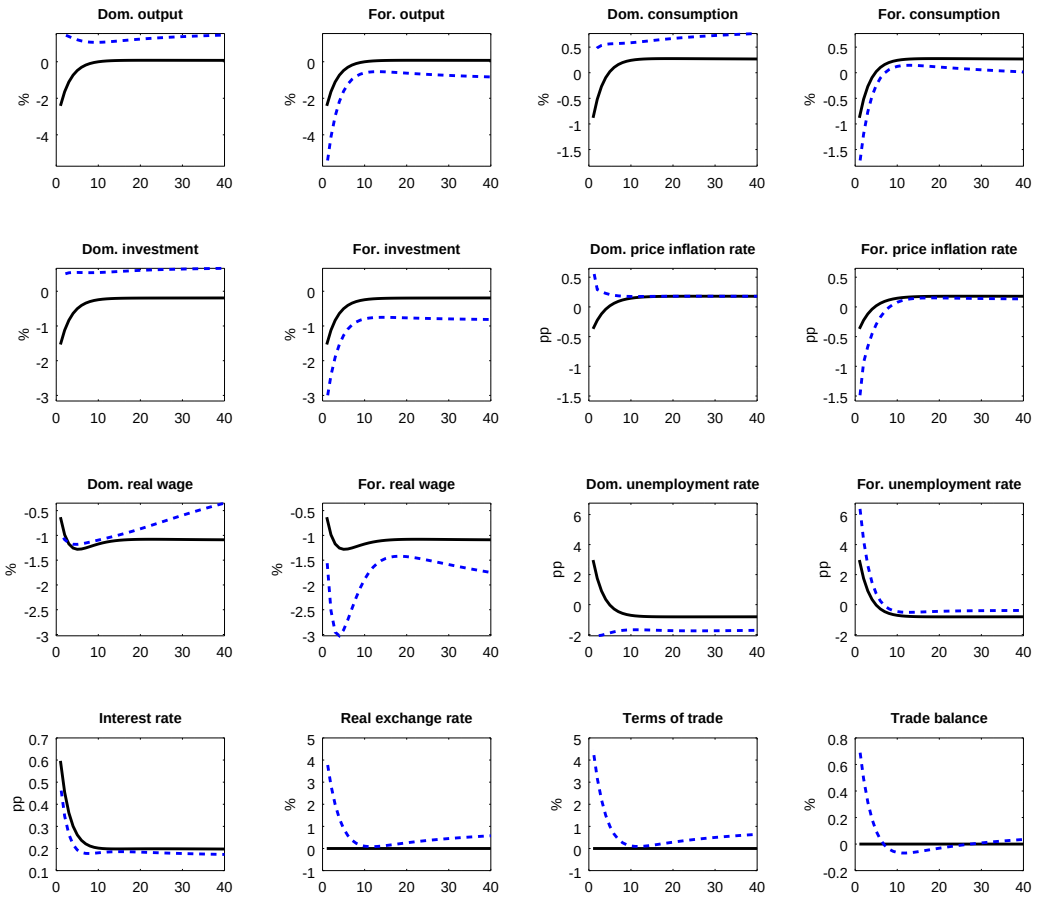

Figure 7: Macroeconomic responses to a monetary policy shock as predicted by the baseline specification (solid line) and a conflictive foreign country/coroporationist domestic country specficition (dashed line).

4 Conclusion

In the present paper, we have extended the closed economy model of Schoder (2017b) to a two-country version of a currency union with a particular focus on wage bargaining. Four main conclusions emerge. Firstly, we have provided a model that is at the same time capable of analyzing the wage bargainging process while a being micro-founded and thus grounded in intertemporal optimization. Standard DSGE models deliver predictions for the wage bargaining process that are at odds with empirical evidence. By modeling the wage formation process as a collective bargaining game, we manage to introduce unemployment into the model that affects bargaining power which in turn affects the real wage. By extending the model to two countries, we can analyze spillover effects of shocks to wages in one economy. Secondly, trade imbalances are slightly more persistent in DSDE models than in DSGE models. Thirdly, when recommendations for policy are form-

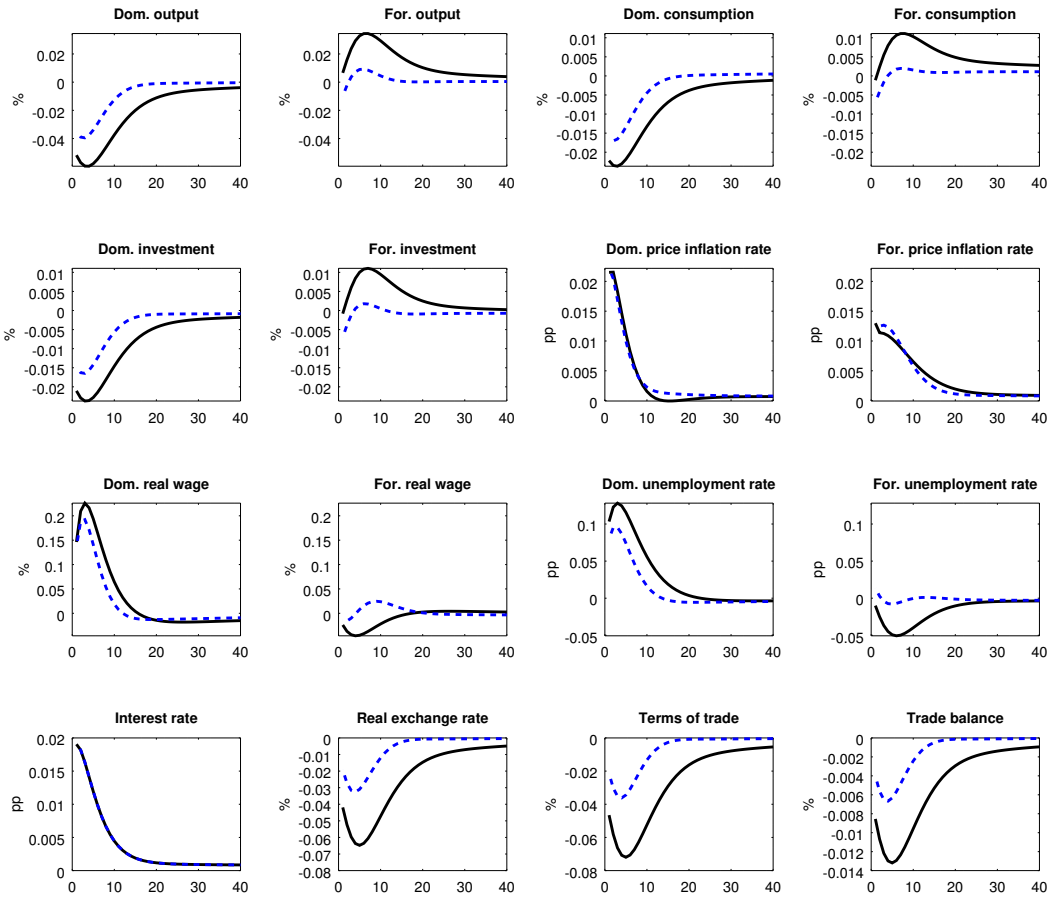

Figure 8: Macroeconomic responses to a wage bargaining power shock in the domestic country as predicted by the baseline DSDE model (solid line) and a DSDE model with trade balance feedback on the wage bargaining power (dashed line).

lated to eliminate current account imbalances, the wage setting regimes of the individual countries need to be understood and respected. A corporatist and a conflictive bargaining system under the umbrella of a common monetary union will react differently when faced with symmetric and asymmetric shocks. The size of the policy shocks and the resulting policy mix should be adjusted accordingly. Finally, taking current account imbalances into accout when in the formulation of wage setting policy may be an advantage. The business cycle (when interpreted as the result of various policy as well as a productivity shock) is decidely more stable when this feedback process is introduced to wage formation in our model because fluctuations are damped.

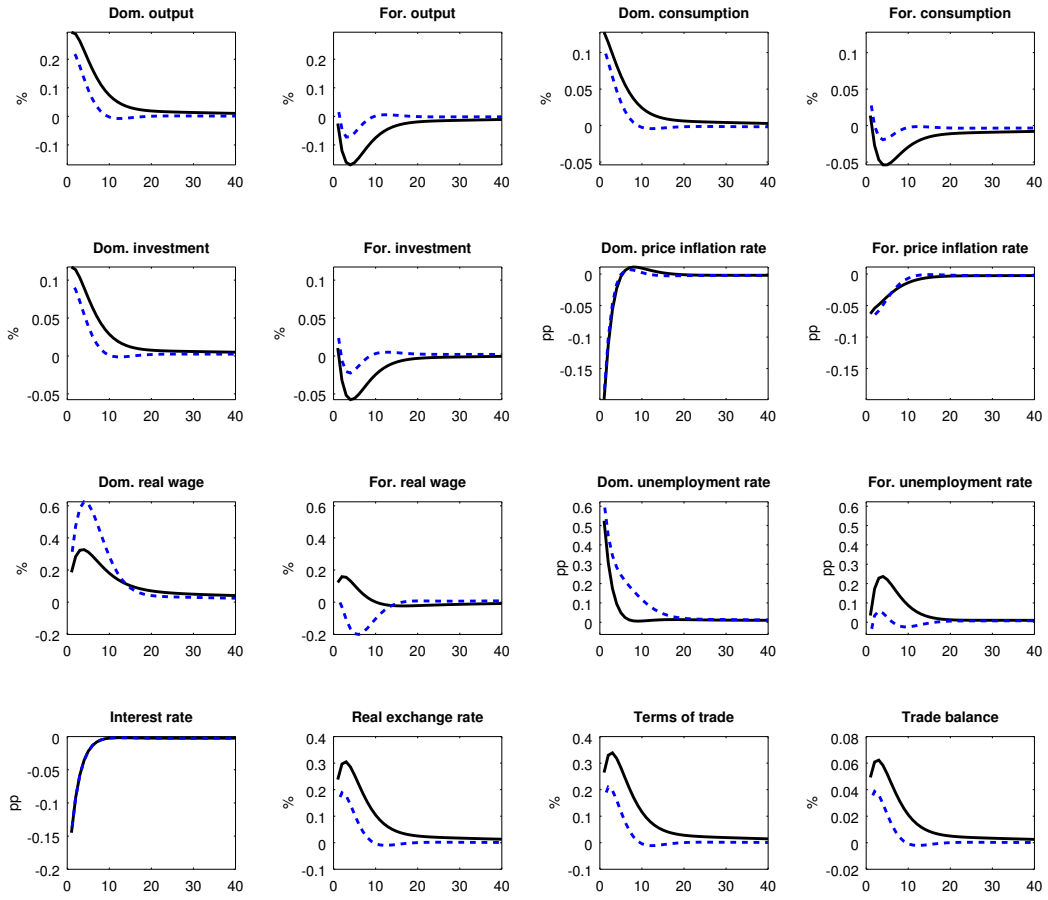

Figure 9: Macroeconomic responses to a productivity shock in the domestic country as predicted by the baseline DSDE model (solid line) and a DSDE model with trade balance feedback on the wage bargaining power (dashed line).

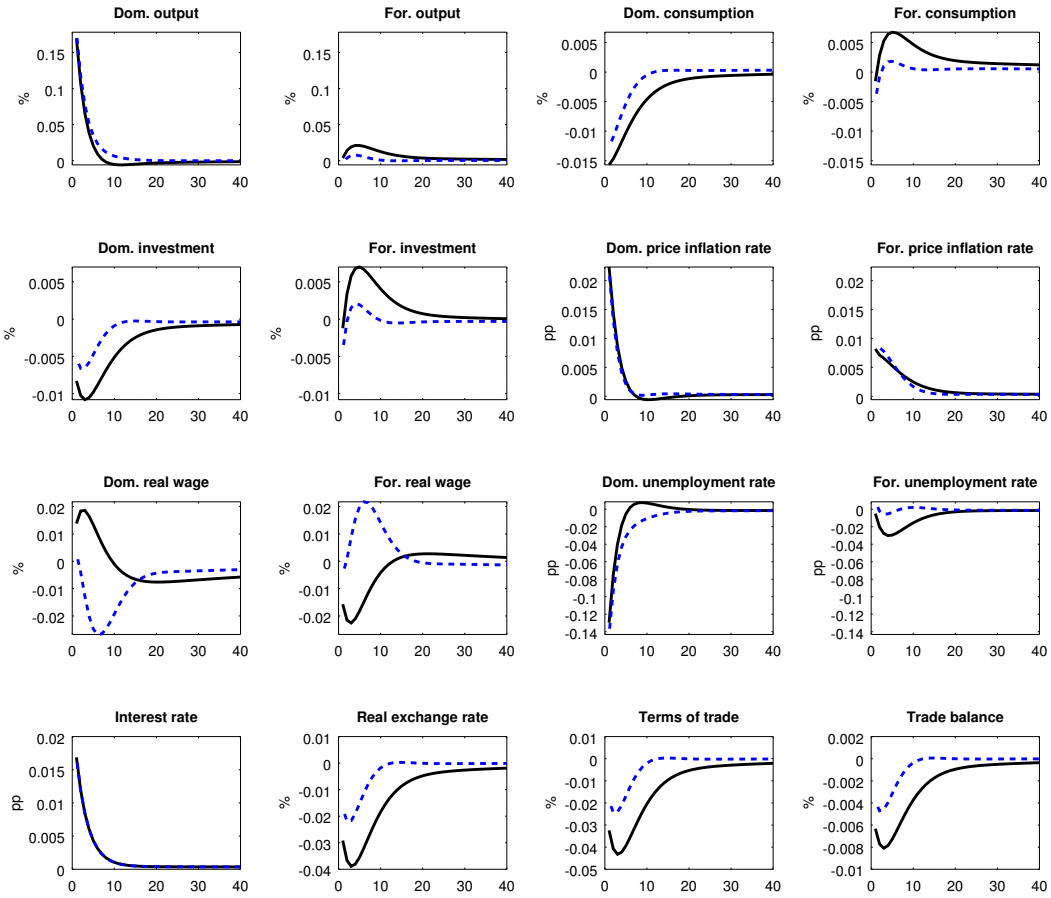

Figure 10: Macroeconomic responses to a government spending shock in the domestic country as predicted by the baseline DSDE model (solid line) and a DSDE model with trade balance feedback on the wage bargaining power (dashed line).

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Appendix A List of model variables and shocks

Domestic variables: $Y_d, C_d, I_d, G_d, T_d, CA_d, CI_d, BA_d, BI_d, N_d, \Lambda_d, K_d, L_d, u_d, Z_d, \omega_d, \varphi_d, \Pi_d, q_d, \Pi_{C_d}, \Pi_{W_d}, \nu_d, p_d, pf, pI_d, \Pi_d, C_d, C_f, I_d, I_f$

Foreign variables: $Y_f, C_f, I_f, G_f, T_f, CA_f, CI_f, BA_f, BI_f, N_f, \Lambda_f, K_f, L_f, u_f, Z_f, \omega_f, \varphi_f, \Pi_f, q_f, \Pi_{C_f}, \Pi_{W_f}, \nu_f, p_f, pf, pI_f, \Pi_f, C_f, C_f, I_f, I_f$

Common variables: E, R, VR, TB, TT

Domestic shocks: VA_d, VG_d, V_{ν_d}
Foreign shocks: VA_f, VG_f, V_{ν_f}
Common shocks: V_R

Appendix B Parameter calibration

Table 1: Parameter calibration

Common parameters:	
ϕ_{rpi}	1.1
$\bar{R}$	1.004
ρ_R	0.7
Domestic parameters:	
Γ_d	1.01
β_d	0.998
D_d	0.002
U_d	$0.3 * D_d$
κ_d	$1 - \beta_d \cdot (1 - D_d)$
η_d	1
δ_d	0.025
ϵ_d	3
ϵ_{i_d}	3
ϵ_{c_d}	3
λ_d	0.15
τ_{i_d}	20
τ_{p_d}	30
$\phi_{\nu_{u_d}}$	2
$\phi_{\nu_{tb_d}}$	20
ρ_{G_d}	0.7
ρ_{ν_d}	0.7
ρ_{A_d}	0.7
$\bar{G}_d$	0.2
$P\bar{I}C_d$	1
$\bar{YK}_d$	0.1
$\bar{Y}_d$	1
$\bar{u}_d$	0
γ_{c_d}	0.95
γ_{i_d}	0.95
Foreign parameters:	equal to domestic ones (symmetric calibration)