The macroeconomics of fiscal consolidations in euro area countries

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Abstract

We quantitatively assess the macroeconomic implications of permanently reducing the public debt-to-gross domestic product (GDP) ratio in euro area countries. The simulations of a currency union dynamic general equilibrium model, calibrated to the euro area, give the following results. First, tax distortions are quantitatively significant. Second, the best fiscal consolidation strategy is to permanently reduce both expenditures and tax rates. Third, the transition is generally not costly, as the GDP and investment would grow, while private consumption would not fall. Finally, spillovers to the rest of the euro area are generally expansionary and .

1 Introduction

Recent forecasts by the European Commission and the International Monetary Fund point to dramatic increases in the level of public debt in the next few years in almost all euro area countries. The grim perspectives of the public accounts are compounded by the very high level of implicit public debt, related to the promises of the health and pension systems in our aging societies. Therefore, inevitably, in the near future will see a renewed debate on how to consolidate the fiscal position.

This paper contributes to the debate by quantitatively assessing the macroeconomic and welfare implications of different region-specific fiscal

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consolidation scenarios in the euro area. We model a single country as part of the euro area in order to properly take into account the role of the common monetary policy and the spillovers from (and to) the rest of the area. We consider Germany as the benchmark, given its relative high size.

Euro area countries are relatively homogenous in terms of GDP components (as private consumption and investment as a ratio to GDP) and also in terms of fiscal variables (as the total level of expenditures and revenues). They mainly differ in size, degree of openness and level of public debt. We therefore repeat our analysis of fiscal consolidation calibrating the model also on the Belgian economy. Belgium has rather different structural features with respect to Germany, given that it is a small economy with a high degree of intra-euro area trade openness and with a relatively higher level of public debt. The analysis of Germany and Belgium, therefore, provides enough cases to assess the situation of most euro area countries.

The basic structure of the model is akin to the Global Economy Model (GEM) developed at the IMF.[1] There are monopolistic competition in the goods and labor markets, standard real and nominal frictions to match the persistence and inertia usually found in the data, an interest rate feedback rule for the monetary authority. Differently from other similar models, ours is rich in the terms of fiscal features, that allow to realistically analyze fiscal issues in a general equilibrium context. Fiscal policy is conducted at regional level. In each region we break down the Ricardian equivalence by introducing distortionary taxes on labor income, capital income and consumption, allowing for a realistic treatment of fiscal policy. On the expenditure side, we depart from the simplifying assumption that public expenditures are "pure waste". We carefully distinguish between different uses of public money. Specifically, we consider spending on final goods and services produced by the private sector, public employment and transfer to families. Decomposing public expenditures in its main components is important, as each one has different macroeconomic implications.[2] In particular, we assume that public spending on private final goods is used as intermediate good and combined with public employment to produce public goods that positively affects the households' utility function. In this way, a trade-off between the welfare-enhancing public good and the misallocation of (goods and labor) resources induced by its production is introduced in the model.

We focus on consolidation scenarios where the German (Belgian) fiscal authority permanently reduces the public debt-to-annual gross domestic

[1] See Pesenti (2008). See also Bayoumi (2004) for a non-technical description of the GEM. Several central banks have developed DSGE models for policy analysis. Among the others, the Fed has developed SIGMA (see Erceg et al. (2006)), the European Central Bank the New Euro Area Wide Model (see Coenen et al. (2007)).

[2] Rogerson (2007) argues that "it is essential to explicitly consider how the government spends tax revenues when assessing the effects of tax rates on aggregate hours of market work." For a formal analysis along these lines, see Leeper and Yang (2006).

product (GDP from now on) ratio target from 65% to 55% (85% to 75%) over a five-year horizon. The scenarios differ in terms of tax rates and expenditure items that are changed to reach the target. The model parameters are calibrated to values commonly used in the literature and to replicate the great ratios of Germany (Belgium) and rest of the euro area. We assume that in the rest of the euro area lump-sum transfers are tuned in order to leave the public debt-to-GDP ratio unchanged.

We run simulations under perfect-foresight and assume that the only shocks perturbing the economy are the German or Belgian fiscal ones. We use Dynare to compute initial and final steady states and related transition path. We abstract from considerations related to lack of credibility, uncertainty, optimal Ramsey policy, the use of fiscal instrument to stabilize business cycle and to fiscal coordination issues between Germany (or Belgium) and rest of the euro area.[3]

Along the transition nominal and real rigidities contribute, jointly with the gradual implementation of fiscal measures, to prolong the adjustment of the economy towards the new long run equilibrium. So we report long run (final steady state) and short-medium run (transition) macroeconomic domestic effects and spillovers to the rest of the euro area. We also provide a measure of the effects on welfare in terms of consumption equivalents. Finally, we perform sensitivity analysis to check for the robustness of results.

Results are as follows. First, we show that fiscal distortions are quantitatively relevant. For a given public debt-to-GDP ratio, tax rate cuts compensated by lower lump-sum transfers have clear welfare-improving implications. To the contrary, increases in expenditures (financed by lower lump-sum transfers) aimed at the provision of welfare-enhancing public goods, have negative welfare effects. The reason is that the increase in welfare related to the higher level of public good is more than compensated by the increase in economic distortions (on private goods and labor supply) associated to its production. Second, and consistently with the above results, the best way to accomplish a reduction in the public debt-to-GDP ratio is by lowering tax rates while, at the same time, reducing expenditures by more than would be needed with unchanged tax rates. In particular, a simultaneous reduction in public expenditures and tax rates that achieves the targeted reduction of the public debt has the highest long run steady-state expansionary effects on GDP and on all its components. In the case of Germany, the former increases by 7 to 10% of the initial steady state level, depending on the exact composition of the adjustment. Moreover, among expenditures it is preferable to cut purchases of goods and services or public employment rather than transfers to households. Similar results are obtained in the case of Belgium. The macroeconomic effects on domestic output, income and aggregate demand are smaller than in the German case, given that the Bel-

[3]On the optimal Ramsey problem see Juillard and Pelgrin (2007).

gium is a more open economy, with a relatively high import weight in the consumption and investment baskets. The domestic Belgian effects, however, are not negligible. Third, in the case of Germany spillovers to the rest of the euro area are expansionary and sizeable (long run GDP in the rest of the euro area increases by 2.5-4%). Spillovers are negligible in the case of Belgium, because of its small size. Finally, on impact and along the transition GDP and investment would grow, while private consumption would not fall. When public purchases (a component of internal demand) or government employment (as GDP includes also the public sector wage bill) are being cut GDP growth is subdued.

Our findings are interesting along several dimensions. We contribute to the debate on the quantitative relevance of the macroeconomic effects of fiscal measures. In his Presidential Address to the AEA discussing the "Macroeconomic Priorities", R. Lucas (2003) argues that the welfare gains from supply side fiscal policies would be sizeable and equivalent to increases of about 5 to 15 percent in overall consumption levels. Also Feldstein (2008) discusses "how the effects of taxes on economic behavior are important for revenue estimation, for calculating efficiency effects, and for understanding short-term macroeconomic consequences." Mankiw and Weinzierl (2006) use standard growth models to assess the supply side effects of tax cuts and conclude that "in all models considered, the dynamic response of the economy to tax changes is too large to be ignored". They also show that the results obtained using the standard neoclassic growth model with infinitely lived agents - the framework considered in this paper - are robust to departures, like that of assuming agents with finite horizons or including a share of rule of thumb consumers.[4]

One of the results that we obtain is that there is a wide margin to reduce public expenditures with limited welfare costs. This conclusion supports those obtained by Afonso, Schuknecht and Tanzi (2005), although from a completely different perspective. Their study applies Data Envelope Analysis to assess the "efficiency frontier" of the public sector in the provision of public services and conclude that the same level of public services could be attained with 1/4 less public spending. This result is surprisingly close to what we find.

Our contribution is also related to the empirical literature on the non-Keynesian effects of fiscal policy.[5] This literature has considered fiscal consolidations (variously defined) of OECD countries in order to obtain some indications on the characteristics that most likely would lead to success-

[4]We have extended the model in order to include non Ricardian (or rule-of-thumb) agents and we confirm the findings of Mankiw and Weinzierl (2006). Results are available from the authors upon request.

[5]See, among the others, Alesina and Perotti (1995, 1997), Giavazzi and Pagano (1990, 1996), McDermott and Wescott (1996), Alesina and Ardagna (1998).

ful (i.e. lasting) adjustments. The main conclusion are that (i) adjustments concentrated on the expenditure side of the budget more than on the revenue side and (ii) large adjustments (measured by the reduction in the debt-to-GDP ratio) tend to have more non-Keynesian effects. The main theoretical argument behind these results is that agents are forward looking and therefore any sustainable reduction in public expenditure would generate a wealth effect (agents foresee less taxes) leading to an increase in consumption, investment and economic activity. This wealth effect could – under certain circumstances (as in cases of very high debt-to-GDP ratio at the beginning of the consolidation phase) – dominate against the (Keynesian) direct depressing effect coming from cuts in public expenditures. Our general equilibrium model formalizes most of these channels and allows weighting them in a sound quantitative manner.

Other papers strongly related to ours are Coenen, McAdam and Straub (2006) and Coenen, Mohr and Straub (2006). In particular, the latter analyzes costs and benefits of fiscal consolidation scenarios in the euro area, using a less detailed description of fiscal policy that we use. Their results point to significant positive long-run effects on the main macroeconomic variables, mainly when the improvement in the budget position is used to lower distortionary taxes.

The paper is organized as follows. Section 2 provides a discussion of the setup of the model. Section 3 presents the results of the baseline fiscal consolidation scenarios. Section 4 discusses the transition dynamics of the different fiscal consolidation strategies, while section 5 provides robustness checks. Section 6 concludes.

2 The Model

In this section we initially illustrate the model setup, focusing mainly on the fiscal features. We then report the calibration and the model-based fiscal consolidation scenarios.

2.1 The Setup

There are two regions, Home and rest of the euro area, having different sizes and sharing the monetary policy and currency. In each region there are households and firms. Each household consumes a final good, which is a composite made of intermediate nontradable and tradable goods. The latter are produced domestically or imported. Households participate in financial markets and smooth consumption by trading a risk-free one-period nominal bond. They also own domestic firms and capital stock. The latter is rented to domestic firms in a perfectly competitive market. All households supply differentiated labor services to domestic firms and act as wage setters

in monopolistically competitive labor markets by charging a markup over their marginal rate of substitution between consumption and leisure.

On the production side, there are perfectly competitive firms that produce the final goods and monopolistic firms that produce the intermediate goods. The two final goods (consumption and investment goods) are sold domestically and are produced combining all available intermediate goods using a constant-elasticity-of-substitution (CES) production function. Intermediate tradable and nontradable goods are produced combining domestic capital and labor, that are assumed to be mobile across sectors. Intermediate tradable goods can be sold domestically and abroad. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We also assume that markets for tradable goods are segmented, so that firms can set two different prices, one for each market. To capture the empirical persistence of the aggregate data and generate realistic dynamics, we include adjustment costs on real and nominal variables, ensuring that, in response to a shock, consumption and production react in a gradual way. On the real side, quadratic costs prolong the adjustment of the capital stock. On the nominal side, they make wages and prices sticky.[6]

In the following section we describe in detail the fiscal policy setup and the households problem. In the Appendix we laid down the rest of the model.

2.2 Fiscal policy

Fiscal policy is set at the regional level. The government budget constraint is:

$$\left[\frac{B_{t+1}^g}{R_t} - B_t^g\right] = (1+\tau_t^c)P_t C_t^g + W_t L_t^g + Tr_t - T_t \tag{1}$$

where $B_t^g \geq 0$ is nominal public debt. It is a one-period risk-free nominal bond issued in the euro area wide market that pays a gross nominal interest rate R_t controlled by the monetary authority of the currency union. The variable C_t^g represents government purchases of goods and services, $W_t L_t^g$ is compensation for public employees (W_t is the nominal wage, L_t^g is the total number of hours worked in the public sector), Tr_t are lump-sum transfers to households. We assume that C_t^g has the same composition as private consumption. Hence it is pre-multiplied by the private consumption price index P_t. Total government revenues T_t are given by the following identity:

$$T_t \equiv \tau_t^\ell W_t L_t + \tau_t^c \left[P_t C_t + P_t C_t^g\right] + \tau_t^k \left[R_t^k K_{t-1} + \Pi_t^P\right] \tag{2}$$

where the τs are tax rates on labor income (τ_t^ℓ), capital income (τ_t^k) and consumption (τ_t^c), L_t is total amount of hours worked (in the public sector,

[6] See Rotemberg (1982).

L_t^g, and in the private sector, L_t^p, that is $L_t = L_t^p + L_t^g$), R_t^k is the rental rate of existing physical capital stock K_{t-1} and Π_t^P stands for dividends from ownership of domestic monopolistic firms.

The public sector combines labor, purchases of goods and services and a constant stock of public building and land, $\overline{BL}_g$) to produce public goods Y^g (as health, education, security, justice, etc...) according to the following CES production function:

$$Y_t^g = \left[(1 - \gamma_{Lg} - \gamma_{Cg})^{\frac{1}{\alpha_g}} \overline{BL}_g^{\frac{\alpha_g - 1}{\alpha_g}} + \gamma_{Cg}^{\frac{1}{\alpha_g}} C_t^{g\,\frac{\alpha_g - 1}{\alpha_g}} + \gamma_{Lg}^{\frac{1}{\alpha_g}} L_t^{g\,\frac{\alpha_g - 1}{\alpha_g}} \right]^{\frac{\alpha_g}{\alpha_g - 1}}$$

where $\alpha_g > 0$ measures the degree of substitutability between the three kinds of input and γ_{Lg}, γ_{Cg} are the weights of government employment and purchases of goods and services, respectively ($0 < \gamma_{Cg} < 1$ and $0 < \gamma_{Lg} < 1$). Both C_t^g and L_t^g are exogenously given.

Given the presence of public employment, and consistently with common practice in the national accounts statistics, we include the public expenditure for wages in the definition of GDP:

$$GDP_t = C_t + p_t^I I_t + C_t^g + p_t^{EXP} EXP_t - p_t^{IMP} IMP_t + w_t L_t^g \qquad (3)$$

where p_t^I, p_t^{EXP}, p_t^{IMP}, w_t are prices of respectively investment, export and import and wage expressed in units of the domestic consumption bundle.

We assume that the government uses a fiscal rule defined on a single fiscal instrument to bring the public debt as a percent of domestic GDP, $b > 0$, in line with its target b^*. We consider alternative instruments among the three tax rates $(\tau_t^\ell, \tau_t^k, \tau_t^c)$ and the three expenditure items (C_t^g, L_t^g, Tr_t), depending on the considered fiscal consolidation scenario.[7] We assume the following fiscal rule:

$$\frac{i_t}{i_{t-1}} = \left(\frac{b_t}{b^*}\right)^{\phi_1} \left(\frac{b_t}{b_{t-1}}\right)^{\phi_2} \left(\frac{GDP_t}{GDP_{t-1}}\right)^{\phi_3} \qquad (4)$$

where i_t is one of the six fiscal instruments considered. Parameters ϕ_1, ϕ_2 and ϕ_3 are lower than zero when the rule is defined on an expenditure item calling for a reduction in expenditures whenever the debt level is above target and for a larger reduction whenever the dynamics of the debt is not converging and/or the GDP growth is positive. To the contrary, they are greater than zero when the rule is on tax rates. Overall,the fiscal setup of the model is able to take into account many implications of different tax and expenditure items. This is essential in order to understand the macroeconomic effects of fiscal consolidation scenarios.

[7] So the scenarios differ for the fiscal item that is exogenously changed by the fiscal authority and the one that is endogenously changed to stabilize the debt according to the fiscal rule.

2.3 Households

In each country there is a continuum of symmetric households. Home households are indexed by $j \in [0; s]$ and Foreign households by $j^* \in (s; 1]$.[8] Households' preferences are additively separable in consumption and labor effort. Households receive utility from consuming and disutility from working L_t hours. The expected value of household j lifetime utility is given by:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\frac{\widetilde{C}_t(j)^{1-\sigma}}{(1-\sigma)} - \frac{\kappa}{\tau} L_t(j)^{\tau} \right] \right\}$$

where E_0 denotes the expectation conditional on information set at date 0, β is the discount factor ($0 < \beta < 1$), $1/\sigma$ is the elasticity of intertemporal substitution ($\sigma > 0$) and $1/(\tau - 1)$ is the labor Frisch elasticity ($\tau > 0$).

The consumption bundle $\widetilde{C}_t(j)$ is given by:

$$\widetilde{C}_t(j) = \left[\omega^{\frac{1}{\theta}} C_t(j)^{\frac{\theta-1}{\theta}} + (1-\omega)^{\frac{1}{\theta}} Y_t^{g\,\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

where $\theta > 0$ measures the degree of substitutability between private (C) and public goods (Y^g) while $0 \leq \omega \leq 1$ is the weight of the private good in the consumption bundle. When $\omega = 1$, the level of the public good does not alter private consumption decisions.

The budget constraint of agent j is:

$$\begin{aligned} \frac{B_t(j)}{(1+R_t)\,\mu_t} - B_{t-1}(j) \quad \leq \quad & (1-\tau_t^k)\left(\Pi_t^P(j) + R_t^K K_{t-1}(j)\right) + \\ & + (1-\tau_t^{\ell}) W_t(j)\, L_t(j) - (1+\tau_t^c) P_t C_t(j) - P_t^I I_t(j) \\ & + Tr_t(j) - AC_t^W(j) \end{aligned}$$

Home agents hold a one-period risk-free bond, B_t, denominated in the currency of the monetary union. The short-term nominal rates R_t is paid at the beginning of period t and is known at time t. It is directly controlled by the monetary authority. A financial friction μ_t is introduced to guarantee that net asset positions follow a stationary process and the economy converge to a steady state.[9] We assume that government and private bonds can be traded internationally in the same market. Households own all domestic firms and there is no international trade in claims on firms' profits. The variable Π_t^P includes profits accruing to the Home household. We assume that profits are

[8] The population of the monetary union is normalized to one. The parameter s is the size of the Home population, which is also equal to the number of firms in each Home sector (final nontradable, intermediate tradable and intermediate nontradable). Similar assumptions holds for $1 - s$ in the rest of the euro area.

[9] Revenue from financial intermediation are rebated in a lump-sum way to agents in the rest of euro area. See Benigno (2009).

equally shared across households. The variable I_t is investment bundle in physical capital and P_t^I the related price index, which is different from the price index of consumption because the two bundles have different composition.[10] Home agents accumulate physical capital K_t and rent it to domestic firms at the nominal rate R_t^k. The law of motion of capital accumulation is:

$$K_t(j) = (1-\delta) K_{t-1}(j) + \left(1 - AC_t^I(j)\right) I_t(j)$$

where δ is the depreciation rate. Adjustment cost on investment AC_t^I is :

$$AC_t^I(j) = \frac{\phi_I}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - \delta\right)^2, \ \phi_I > 0$$

Finally, Home households act as wage setters in a monopolistic competitive labor market. Each household j set her nominal wages taking into account of labor demand and adjustment costs AC_t^W on the nominal wage $W_t(j)$:

$$AC_t^W(j) = \frac{\kappa_W}{2}\left(\frac{W_t(j)}{W_{t-1}(j)} - 1\right)^2 W_t L_t, \ \kappa_W > 0$$

The costs are proportional to the per-capita wage bill of the overall economy, $W_t L_t$. Similar relations hold in the Foreign country, with the exception of the intermediation frictions in the financial market.

2.4 Calibration

The model is calibrated at a quarterly frequency. We set some parameter values so that steady-state ratios are consistent with 2007 national account data, which are the most recent and complete available data. We choose to not use projection for 2010 public debt-to-GDP ratios, even if available, for two reasons. First, remaining data on fiscal variables are not available yet or are surrounded by a high degree of uncertainty. Second, given that it is likely that 2010 public expenditure and debt are higher than the current levels, our estimates represent a lower bound of the effects, so that we put ourselves on the conservative side. For remaining parameters we resort to previous studies and estimates available in the literature.[11] Table 1 contains parameters related to preferences and technology. Parameters with a "$*$" are related to the rest of the euro area region. We assume that discount rates and elasticities of substitution have the same value across the two regions. The discount factor β is set to 0.9875, so that the steady state real interest rate is equal to 5 per cent on an annual basis. The value for the intertemporal elasticity of substitution, $1/\sigma$, is 1. The Frisch labor elasticity

[10] See the Appendix for more details.

[11] Among others, see Forni, Gerali and Pisani (2009) and Forni, Monteforte and Sessa (2009).

is set to 2. The weight of the private good ω in the utility function is 0.8.[12] The elasticity of substitution between private and public goods, θ, is set to 1.5.[13] The depreciation rate of capital δ is set to 0.025.

In the production functions of tradables the elasticity of substitution between labor and capital is set respectively to 0.85 for Germany and Belgium and 0.9 for the rest of the euro area. In the German and Belgian production functions of nontradables the elasticity is set to 0.79, for the rest of the euro area to 0.95. The bias towards private capital is set to 0.75 in the German and Belgian tradable sectors, and to 0.7 for the rest of the euro area. The bias is set to 0.7 in the nontradable sector of each region. In the German and Belgian production functions of the public sector the elasticity of substitution between inputs (labor, stock of public capital and intermediate goods) α_g is equal to 0.79, to 0.95 in the rest of the euro area. The biases towards intermediate goods γ_{Cg} and labor γ_{Lg} are set to 0.15.

In the final consumption and investment goods the elasticity of substitution between domestic and imported tradable is set to 1.5, while the elasticity of substitution between tradables and nontradables to 0.5. The bias for the composite tradable is set to 0.55 for Germany, to 0.8 for Belgium and to 0.5 for the rest of the area. The biases for the domestically produced tradables and for composite tradable goods are set to match the Germany (Belgium)-rest of the euro area import and export to GDP ratios. The population size of Germany (Belgium), n, is set to 0.3 (0.03) and we normalize the population of the euro area to 1.

Table 2 reports gross markups in the tradable, nontradable and labor markets. We assume markups are higher in the nontradable and labor markets. We obtain these figures by calibrating the sector-specific elasticities of substitution between varieties.[14]

Table 3 contains parameters that regulate the dynamics. Adjustment costs on investment change are set to 3.5. Nominal wage and price quadratic adjustment costs are set in such a way to get an average frequency of wage and price adjustment roughly equal to 4 quarters. The two parameters regulating the adjustment cost paid by the Home households on their net financial position are set to 0.01.

Parametrization of systematic feedback rule followed by the fiscal and monetary authorities are reported in Table 4. In the fiscal policy rule (4) we set $\phi_1 = 0.5$, $\phi_2 = 5$ and $\phi_3 = 5$ for Germany, Belgium and rest of

[12] There is not clear empirical evidence that we can use in the calibration of this parameter. We check the robustness of the results in section 5.

[13] In the robustness section we will discuss also the results when the elasticity of substitution is lower (we will assume $\theta = 0.8$). Most contributions assume that private and public consumption are substitutes. For example, Prescott (2002) assumes they are perfect substitutes.

[14] For an analysis of the macroeconomic effects of different degree of markups in a model similar to the one used in this paper, see Forni, Gerali and Pisani (2009).

the euro area. The chosen values allow reaching the public debt target in more or less ten years in all the simulations. Their sign is positive when the fiscal instrument in the rule is a tax rate, it is negative when the instrument is a public expenditure. The central bank of the euro area targets the contemporaneous euro area wide consumer price inflation (the corresponding parameter is set to 1.7) and the output growth (the parameter is set to 0.4).[15] Interest rate is set in an inertial way and hence its previous-period value enters the rule with a weight equal to 0.9.

Table 5 reports model-based and actual steady-state great ratios and tax rates under our baseline calibration. Private consumption, investment, bilateral imports and exports match the data rather well. In particular, the Belgian economy is more open than the Germany (the shares of exports and imports are higher). We assume a zero steady state net foreign asset position for the German and, alternatively, Belgian economy. This implies that - in steady state - the *net* financial position of the German private sector equals the level of the German public debt (a similar assumption holds for Belgium).[16]

As for fiscal policy variables, it must be noted that some expenditure items (as purchases C^g as a ratio to GDP) are perfectly matched as they are exogenous. For other items, as the public wage bill and the interest expenditure, we calibrate the share of public employees over the total number of employees and the level of public debt-to-annual GDP ratio to replicate the actual data. As the wage and interest rates are endogenous, however, we don't match exactly the corresponding expenditure components. Tax rates are calibrated using effective average tax rates estimates for 2007 taken from Eurostat (2008). The tax rate on wage income τ^ℓ is set to 39 per cent in Germany, 42 per cent in Belgium and to 34 in the rest of the euro area. The tax rate on capital income τ^k respectively to 21, 20 and 23, while the tax rate on consumption τ^c to 20 and to 22. The public debt-to-yearly GDP ratio is calibrated to 65 per cent for Germany, 85 for Belgium and to 60 for the rest of the euro area.

[15]The euro area-wide consumer price inflation rate and GDP are weighted (by the regional size) geometric average of the corresponding regional variables.

[16]The zero net foreign asset assumption holds in both the initial and final steady state, but not along the transition. We have done robustness analysis assuming steady state German net financial position different from zero in the initial steady state and a value different from zero in the final steady state. Results, available from the authors upon request, are not greatly affected. This is to be expected. Because we have a monetary union framework, we don't have a flexible nominal exchange rate that induces "valuation effects" on the financial position through its fluctuations.

3 Results

In what follows we simulate the model to quantitatively assess the macroeconomic effects of several fiscal consolidation strategies implemented in the Home economy, alternatively calibrated to Germany and Belgium. The analysis of Germany and Belgium provides enough cases to assess the situation of most euro area countries. As argued, in fact, euro area countries are relatively homogenous in terms of expenditure shares of GDP and also in terms of fiscal variables (as the total level of expenditures and revenues). They mainly differ in size, in the degree of openness and in the level of public debt. In section 5 we provide robustness exercises along several dimensions (size and openness of the country among the others) in order to show how one can adjust the basic insights gained from the German and Belgian cases to the rest of euro area countries. For public debt, simulations show that the initial level of public debt-to-GDP ratio does not greatly affect the main results, that mainly depend upon the initial level of distortionary public expenditure and taxation. To save on space we do not report them.[17]

We initially assess the optimal composition of the budget (in terms of expenditures and revenues) for given level of Home public debt-to-GDP ratio (section 3.1). We proceed in two related steps. First, we show that reductions in tax rates or expenditure items can have significant welfare gains. Second we simulate a simultaneous cut in tax rates and expenditure items such that the debt level remains unchanged and compute the level of tax rates and expenditure items that maximizes the welfare level. For simplicity, we focus on steady state comparisons and discuss results only for Germany, as the results for Belgium are similar.

In section 3.2 we present the main results of the paper, those regarding fiscal consolidation. We permanently reduce the Home public debt-to-annual GDP ratio by 10 percentage points over a five-year horizon and show results for both Germany and Belgium. The reduction can be obtained through adjustments in revenues and expenditures by appropriately changing the fiscal instrument in the fiscal rule (rule). We show the long run (steady-state) and dynamic (transitional) macroeconomic and welfare impact of the possible alternative fiscal consolidation strategies.

The main result is that reductions of fiscal distortions have sizeable expansionary effects on the Home economy and positive effects on Home welfare. In particular, fiscal consolidations based on simultaneous reductions of tax rates and expenditure items can have strong positive effects on activity and welfare both in the long and short run.

[17] They are available from the authors upon request.

3.1 Optimal expenditure and revenue composition for given level of public debt

To show the quantitative relevance of tax and expenditure distortions, that is how much we can improve welfare if we reduce them, we simulate under perfect foresight the effects of compensated reductions in the level of distortionary taxation and government expenditures. These exercises also help in understanding the transmission mechanism of the model and the results of the consolidation scenarios, reported in the next section. The reductions in *tax distortions* are achieved via reductions in tax rates compensated by reductions in lump-sum transfers. The reduction in *expenditure distortions* is obtained reducing C^g and L^g while at the same time increasing transfers. Remember that in our setup not only tax rates, but also expenditures are distortionary as they change the optimal allocations of private agents (through both the wealth effect and the public goods in the utility function).

Table 6 shows the percentage changes with respect to the initial steady state levels for the main macroeconomic variables in Germany. We report also the percent change in welfare between initial and final steady state. The measure is expressed in terms of consumption equivalents, that is the constant percentage change in consumption level ($\widetilde{C}$) that would deliver the same utility as the one achieved in the scenario under consideration. The measure does not take into account the welfare effects during the transition, that are illustrated in the next section.

The first three columns of the table show the long-run effects of reducing transfers to households (Tr) by 1 per cent of GDP and exactly compensating this expenditure reduction with tax rates reductions (either on labor income, capital income or consumption) as to leave the level of public debt as a ratio to GDP unchanged. Since transfers are in the model equivalent to a negative lump-sum tax, this procedure delivers a reduction in tax rates leaving unchanged the total amount of net taxes (that is taxes minus transfers, as a percentage of GDP) that agents have to pay.

The table shows that the reduction in tax rates, compensate by lower lump-sum transfers, produces an increase in welfare between 0.4 and 1.2 per cent. The reduction in labor income tax rate (column 1) induces a decrease in real wages (w) while at the same time a substantial increase in after-tax real wages ($(1-\tau^{\ell})w$), employment and consumption. The increase in employment brings about also an increase in investment. Similarly, the cut in consumption tax rate (column 3) leads to a reduction in real wages and to an increase in employment. At the same time it favors consumption over investment and therefore limits capital accumulation. In sum, a cut in this tax rate leads to a limited increase in employment, investment, output and welfare. Also, cuts to the consumption tax rate apply to both domestically produced and imported goods, while cuts to labor income or capital income

taxes reduce the cost of production only of domestically produced goods. Finally, in the case of a reduction in the capital income tax rate (column 2), the increase in investment drives up output, while consumption is subdued as the reduction in capital income taxes makes it relatively more costly.[18]

As the welfare and efficiency gains related to cuts in consumption tax rates tend to be significantly smaller than those due to cuts in labor and capital income rates, the analysis in the rest of the paper will focus on those two latter rates. It must be kept in mind, however, that consumption taxes are still in the model (although fixed) and contribute to the calibration of steady state values.

The columns 4 and 5 of the table show the effects of reducing *expenditure distortions*. This is achieved by increasing lump-sum transfers by 1 per cent of GDP while at the same time reducing by the same amount government purchases (column 4) or public employment (column 5). As the increase in transfers corresponds to a reduction in net taxes, without reductions in tax rates, the move achieves a reduction in the overall level of taxation without changing tax rates. On the one hand, welfare improves due to the positive income effect; on the other, the reduction in the provision of the utility-enhancing public good has a negative effect on welfare. Overall, in column 4 the welfare gain is negative, while in column 5 the welfare gain is positive, although tend to be smaller than the gain obtained by reducing labor and income tax rates. GDP decreases, mainly because of the reduction in its public component (both purchases of goods and services or the public wage bill are part of GDP; see equation 3).

Up to this point we have analyzed the gains in implementing compensated tax rates and expenditure cuts. We now assess the trade-off existing when the reduction in tax rates is achieved through the reduction in welfare-improving public expenditures. That is, the cuts in tax rates are compensated not by lump-sum transfers but via reduction in purchases C^g or public employment L^g, that are used to produce the public good.

In Figure 1 we report the welfare level for different combinations of labor and capital income taxes, while setting all other parameters at their baseline values. The figure plots the welfare level assuming that the reduction in tax rates is compensated by cuts in one of the three expenditure items (purchases C^g, public employment L^g and transfers Tr) in order to leave the public debt-to-GDP ratio unchanged. The point in the figure labelled *initial steady state* has a welfare level normalized to 1 (in the initial steady state $\tau^\ell = 0.390$ and $\tau^k = 0.207$). The picture shows that reducing one or

[18]The size of the welfare gains are rather robust to alternative calibrations. In particular, we have done some robustness check with respect to the parameters of the production function (as the elasticity of substitution between labor and capital) and utility function (as the intertemporal elasticity of substitution and the level of the disutility of the working effort) and there are not substantial changes in the results.

both rates increases the welfare level, regardless of the expenditure item that is being reduced. Welfare increases almost linearly when the reduction in tax rates is compensated by cuts in transfers, as the change simply reduces tax distortions. When the expenditure reduction is concentrated on C^g, the welfare increases up to a maximum of about 3.5%. At the maximum τ^ℓ is at about 21% and τ^k at about 11%. This implies a cut in the former of 18 points and in the latter of 10 points. When it is concentrated on L^g, welfare goes up to about 2% (with τ^ℓ at 24% and τ^k at 16%). In both cases total expenditure in Germany would decrease by about 1/4, roughly the same number that Afonso, Schuknecht and Tanzi (2005) find, using a completely different approach.

To sum up, based on our calibration, tax and expenditure distortions seem to be significant. Moreover, there is a wide margin to cut tax rates and expenditures while increasing the level of welfare. In particular, our results suggest that welfare would increase for simultaneous cuts in the labor and capital income tax rates, compensating the revenue loss by reducing public expenditures.

3.2 The long-run effects of the fiscal consolidation

We now consider scenarios where the target level of debt-to-GDP ratio is permanently reduced by 10 percentage points over five years in Germany and, alternatively, in Belgium. The size of this reduction is realistic, although rather ambitious.

We consider fully credible and fully anticipated consolidation plans and run perfect-foresight simulations. In this section we compare steady states before and after the consolidation, while in the next one we study the adjustment path of endogenous variables towards the new steady state level.

Table 7a and 7b report steady state results, for Germany and Belgium respectively. The first two columns - labelled (B, τ^ℓ), (B, τ^k) - assume that the consolidation is achieved increasing along the transition one tax rate at a time (on labor income and capital income, respectively) following the fiscal rule (4), leaving public expenditure for goods and services (as ratio to GDP) and for employment (as ratio to total employment) unchanged.[19]

In the next three columns of Table 7 - labelled (B, C^g), (B, L^g) and (B, Tr) - the consolidation is achieved imposing along the transition the fiscal rule defined on one expenditure item at a time (purchases of goods

[19]Results are only slightly different if we assume that expenditures remain unchanged in real terms, instead of as a percentage of GDP. Since GDP increases for all three tax cuts, fixed expenditures in real term would imply that they would decrease in terms of GDP. Therefore, the positive effects (on the macro variables and on steady state welfare) would be larger. As expenditures, especially in Italy, tend to grow with GDP, we feel more confident with our baseline assumption.

and services, public employment and transfers, respectively), leaving tax rates unchanged. The columns after the fifth consider scenarios where, in order to reduce the Home public debt-to-GDP ratio to the target, tax rates are exogenously reduced by five percentage points and one expenditure item at a time is endogenously reduced through the fiscal rule. By reducing both tax rates by 5 percentage points, total primary expenditures have to be cut by about 4% of GDP, quite a significant amount.[20]

The intuition behind the steady-state results is as follows. In the scenarios of tax-based consolidation, tax rates are increased along the transition. Once the debt target is achieved and interest expenditure on public debt is reduced, tax rates can stabilize at a final steady-state level lower than the initial one. Similarly, in the scenarios of public expenditure-based consolidation, public expenditures are cut along the transition but eventually end up to a final steady-state level higher than the initial one, substituting for the lower interest outlays. Lastly, reducing both expenditures and taxes along the transition implies that the lower steady-state interest rate payment is divided between lower expenditures and taxes.

The first two columns of Table 7a (German case) shows that reducing tax rates induces an increase in output, which is slightly stronger for lower labor income tax rate. In the latter case there is a positive reaction in hours worked, that induces higher consumption (households substitute consumption for leisure) and investment (capital is more productive when employment is higher). In the case of lower capital income tax, investment strongly increases while the increase in consumption and employment is relatively low.

Columns 3-5 show the effects of higher steady state public expenditure for goods, employment and lump-sum transfers. The latter have zero effect, given that the net financial asset position of the Italian economy (equal to the sum of private and public sector asset positions) is equal in both the initial and final steady state and change in transfers do not affect households' first order conditions. In the other two cases, output increases by the same amount, albeit for different reasons. Higher public expenditure for goods and services induces a decrease in private demand for consumption and an increase in supply driven by employment and capital (higher investment). Higher public expenditure for employment induce an increase in the wage component of output (see equation 3), while private demand decreases.

Columns 6-8 report the results assuming a reduction in labor income taxes equal to 5 percentage points. Output increases less when public consumption and employment are reduced, because, differently from lump-sum transfers, they directly affect the GDP. To the contrary, private consumption

[20] We could have considered larger tax cuts. These, however, would have implied reductions in total primary expenditures larger than 4% of GDP, an amount difficult to achieve in the horizon that we consider for the transition.

increases more, as more resources are made available for private (households and firms) demand.

A similar picture emerges from columns 9-11. Similarly to the previously considered scenarios, in the new steady state both capital income taxes and public expenditures are reduced. Also in this case, the lower increase in GDP and the higher increase in private consumption is associated to the C^g and L^g scenarios.

A similar ranking and logic apply when both taxes are simultaneously reduced (columns 12-14). There are expansionary effects on the economic activity, that are roughly equal to the sum of effects obtained when tax reductions are implemented separately.

The results for Belgium (Table 7b) are similar. The macroeconomic effects in Belgium are smaller than in Germany. The reason is that the Belgian economy is more open than Germany (the import contents of consumption and investment baskets are higher), so reductions in tax rates and public expenditures have a lower expansionary effect on domestic output, income and, as a consequence, aggregate demand. However, even if smaller than in the German case, the effects are not negligible.

We conclude that all tax-based reforms have positive effects on the steady state welfare, which increases with respect to the initial one. The biggest effect is obtained when all taxes and expenditures are reduced. This means that utility provided by the public good is more than compensated by the distortions associated to taxation, public employment and purchases. Consistently with this statement, the steady state welfare deteriorates in the scenarios reported in columns 4 and 5, when tax rates are not changed and public expenditures increase in the steady state.

Finally, spillovers to the rest of the euro area are significant in the case of Germany, while they are negligible in the case of Belgium. The effects on the rest of the euro area, relative to the domestic ones, are approximately equal to the relative size of the country. They are generally positive, given that the expansionary effects of reforms on the Home supply side imply higher Home imports and cheaper Home goods for all households in the area. Consistently, the Home terms of trade, defined as the price of Home imports to the price of Home exports (both expressed in terms of Home consumption units), deteriorate while the Home real exchange rate, defined as the ratio of rest of euro area to Home consumer prices, depreciates.

Overall, the main result is that in the euro area country specific fiscal consolidation strategies that reduce taxes and public expenditures have long-run expansionary effects on the domestic production and hence on economic activity and welfare as well as positive spillovers on the rest of the euro area.

4 Transition dynamics

In the previous section we have seen that the permanent reduction in the public debt-to-GDP ratio can induce a significant long run steady-state increase in economic activity and welfare gains when steady state expenditures and revenues are reduced at the same time. In this section we analyze the related transition from the initial steady state to the final one. After a permanent fiscal shock, the economy does not jump immediately from one steady state to the other, because (a) the shock is implemented in a gradual manner and (b) presence of nominal and real rigidities (nominal sticky prices and wages, adjustment costs on investment) slows the adjustment process.

In the following we focus on scenarios where - over a five-year horizon - the target level of the debt-to-GDP ratio permanently decreases by 10 percentage points and both labor and capital income tax rates are cut by 5 percentage points. As shown in the previous section, this policy strategy induces the higher increase in the long-run steady state welfare (columns 12-14 in Table 7a and 7b). As usual, we consider three scenarios. The first (*scenario* C^g) corresponds to the case where the cut falls on public expenditure for intermediate goods. In the second (*scenario* L^g) the cut falls on the expenditure for public employment. Finally, the *scenario* Tr is characterized by a reduction in lump-sum transfer to households. Each expenditure item is adjusted according to the fiscal rule (4). In order to save space we will report results only for the case of Germany.[21]

Figure 2 shows the path of the main fiscal variables and of GDP, while Figure 3 the path of the remaining main macroeconomic variables. Figure 2 shows that the path of public debt is similar across scenarios. It slowly converges to the target in about 10 years. Also the GDP show a similar path across scenarios. It is always above the baseline and increases gradually over time. The other macroeconomic variables display a somehow different pattern depending on the type of fiscal consolidation considered (Figure 3). In the scenario C^g there is a strong increase in consumption of private goods on impact, driven by the amount of resources made available by the lower public good. The Home inflation rate increases, contributing to lower the domestic real interest rate (not reported). The latter decreases because the increase in domestic inflation is not compensated by an increase in the euro area wide nominal interest rate. As employment increases and the supply of goods expands, compensating for the increase in aggregate demand, the inflation rate moderates and consumption slows. In the medium run consumption persistently increases, as tax distortions and public expenditures are reduced. In the other two scenarios consumption does not increase on impact, as the cut in transfers or the public wage bill reduces households disposable income and therefore moderates initially the increase in private

[21] Results for Belgium are similar. They are available from the authors upon request.

consumption.

The described macroeconomic paths have a positive effect on welfare. Table 8 reports a measure of welfare along the transition path and in the final steady state for Germany and Belgium. It is measured in terms of consumption equivalents, that is the constant change, x, in initial steady state (ss) consumption that induces the same discounted flow of utility as the actual one, that is:

$$x \quad s.t. \quad \sum\nolimits_{i=1}^{\infty} \beta^i U\left(xC_{ss,}L_{ss}\right) = \sum\nolimits_{i=1}^{\infty} \beta^i U\left(C_{i,}L_i\right)$$

According to our results, consolidations based on simultaneous reductions in tax rates and public expenditures on employment and purchases of goods and services produce the highest increase in welfare, due to the strongest wealth effect associated to the reduction in fiscal distortions. This is true in general for both Germany and Belgium.

5 Robustness

In this section we perform robustness checks on important dimensions of the model. In Table 9 we show how the results for Germany concerning the long run effects of the fiscal consolidation change as we change size and openness, as these are the dimensions that most differ among euro area countries.[22]

We then show that our result are robust to changes in some other important parameters of the model (Table 10), such as the elasticity of labor supply, the weight (ω) of the public good in the utility function and its degree of complementarity/substitutability with the private one (θ). The latter checks are meant to increase the negative welfare effects of cutting expenditures and see whether, for realistic alternative calibration of these parameters, our main results (in particular, that the positive effects due to tax cuts more than compensate the negative effects coming from expenditures cuts) can be overturned.[23]

[22] As for the public debt, steady state results are not greatly affected by different levels of debt to GDP. This is mainly due to the fact that in our model the steady state interest rate is not affected by its level (as it would be for example in an OLG model). Therefore different sizes of debt affect the economy only through different levels of interest rate expenditures. This effect in our baseline scenario is not very significant, as the reduction we assume for the public debt (10 percentage points) entails a limited decline in interest expenditure (around 0.5 per cent of GDP). It must be said that the cross-country empirical evidence on the relation between level of debt and the real interest rate is rather weak (Ardagna, Caselli and Lane 2005).)

[23] We have also evaluated the robustness of our results with respect to the introduction of a share of non Ricardian agents (NR) equal to 35 per cent. Non Ricardian agents are assumed to consume their current disposable income, that is:

$$(1+\tau_t^c)P_t C_t^{NR}(j) = (1-\tau_t^{\ell})W_t(j)\,L_t^{NR}(j) + Tr_t(j)$$

The first three columns of Table 9 report the baseline scenario. Columns 4-6 report results obtained by increasing the German degree of openness to the Belgian level. Finally, columns 7-9 report results when German openness and size are the same as the Belgian ones. The main result is that both openness and size reduce the magnitude of the domestic macroeconomic effects of the consolidation, given that higher openness and lower size imply a high share of imported tradables in the consumption and investment bundles. Note that the lower size contributes to increase the welfare, because it increase the monopolistic power of the country relatively to the rest of the euro area (the supply of Home tradable goods becomes smaller), and hence limits the deterioration of the international relative prices, favoring the Home purchasing power.

As in Table 9, the first three columns of Table 10 report our baseline scenario (same as in the last three columns of Table 7). The columns from forth to sixth assume $\tau = 3$, thus a Frisch labor elasticity of 0.5 (instead of 2 as in the baseline scenario), a rather extreme value given that most estimated models place this elasticity in a range between 1 and 2. Results are somehow expected: employment increases by less, leading to a lower increase in investment, consumption and output. The columns (7)-(9) replicate the baseline scenario assuming $\omega = 0.5$ (instead of 0.8), thus giving a weight equal to one half to the public good in the consumption bundle. In this case we observe a drop in the welfare gains of the fiscal consolidation, consistently with the fact that it requires cuts in expenditures. The drop is higher especially for cuts to public employment and purchases, as these expenditure items affect directly the production of the public good, while is much more limited for cuts to transfers. It must be noted, in any case, that welfare gains remain in general positive and significant. As for the effects on the macro variables, since public and private goods are substitutes (in the baseline we assume $\theta = 1.5$), the drop in the public good leads to a slightly higher increase in private consumption.

In the next three columns, (10)-(12), we assume that public and private goods are complements ($\theta = 0.8$). This implies that reductions in purchases or public employment (that reduce the provision of the public good) decrease the marginal utility of private consumption. Therefore in this scenario private consumption increases by less, although moderately.

Overall these robustness checks broadly confirm our baseline results. In particular in all cases we find that reductions in the debt-to-GDP ratio obtained via a concomitant reduction in expenditures and revenues is welfare improving. In general, the consequences of the different assumptions on the

The results - not reported - are only slightly different from the baseline. This is in line with the finding of Mankiw and Weinzierl (2006), among others. The reason is that non Ricardian agents do not smooth consumption and therefore do not contribute to pin down the steady state level of the capital stock.

parameter values that we have considered are rather limited, both on the macroeconomic variables and on the welfare levels.

6 Concluding remarks

We have simulated a monetary union DSGE model of the euro area to analyze the macroeconomic and welfare effects of alternative fiscal consolidation strategies in euro area countries. We have presented the effects of a permanent reduction of the public debt-to-GDP ratio of 10 percentage points achieved over five years. We have shown that a significant debt-to-GDP ratio reduction obtained via reducing both expenditure and taxes can be welfare improving. The order of magnitude of these welfare gains is comparable with those suggested by Lucas (2003).

Our simulations have highlighted a series of other results. A simultaneous reduction in public expenditures and tax rates that achieves the targeted reduction of the public debt has long run steady-state expansionary effects on the region-specific GDP and on all its component. The former increases by 7% to 10% of the initial steady state level for Germany (by 5% to 7% for Belgium), depending on the exact composition of the adjustment. For a sizable country (as Germany) the spillovers to the rest of the euro area are expansionary and significant (long run GDP in the rest of the euro area would increase by 2.5-4%). For a small economy such as Belgium, the spillovers to the rest of the euro area are small. Finally, along the transition GDP, private consumption and investment do not fall. The results are robust to alternative calibrations.

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Appendix

In this Appendix we report a detailed description of the model, excluding the fiscal policy part and the description of the Households optimization problem that are reported in the main text.

A The setup

There are two regions, Italy and rest of the euro area, having different sizes and sharing the currency and the central bank. In each region there are households and firms. Each household consumes a final composite good made of non-tradable, domestic tradable and imported intermediate goods from the rest of the area. Households have access to financial markets and smooth consumption by trading a risk-free one-period nominal bond. They also own domestic firms and capital stock, which is rent to domestic firms in a perfectly competitive market. Households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive markets by charging a markup over their marginal rate of substitution.

On the production side, there are perfectly competitive firms that produce the final goods and monopolistic firms that produce the intermediate goods. The three final goods (a private consumption, a private investment and a public consumption good) are produced combining all available intermediate goods in a constant-elasticity-of-substitution matter. Tradable and non-tradable intermediate goods are produced combining capital and labor in the same way. Tradable intermediate goods are split in domestically-consumed and export goods. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We assume that Italy and the rest of the euro area are segmented markets and the law of one price for tradables does not hold. Hence, each firm producing a tradable good sets two prices, one for the domestic market and the other for the export market. Since the firm faces the same marginal costs regardless of the scale of production in each market, the different price-setting problems are independent of each other.

To capture the empirical persistence of the aggregate data and generate realistic dynamics, we include adjustment costs on real and nominal variables, ensuring that, in response to a shock, consumption and production do not immediately jump to a new long-term equilibrium. On the real side, quadratic costs prolong the adjustment of the capital stock. On the nominal side, quadratic cost make wage and prices sticky.

Imperfect competition in product and labor markets is reflected in markups over marginal costs. The elasticity of substitution between products of different firms determines the market power of each profit-maximizing firm.

The setup in the labor market is similar. Each worker offers a differentiated kind of labor services that is an imperfect substitute for services offered by other workers. The lower the degree of substitutability, for example because of skill differences or anti-competitive regulation, the higher is the markup and the lower employment in terms of hours. Hence, markups are modeled by a single parameter.

A The model

In what follows we illustrate the Home economy (Italy). The structure of the Foreign economy (the rest of the euro area) is similar and to save on space we do not report it.

A Final consumption and investment goods

There is continuum of symmetric Home firms producing Home final non-tradable consumption under perfect competition. Each firm producing the consumption good is indexed by $x \in (0, s]$, where the parameter $0 < s < 1$ is a measure of country size. Foreign firms producing the Foreign final consumption goods are indexed by by $x^* \in (s, 1]$ (the size of the monetary union is normalized to 1). The CES production technology used by firm x is:

$$A_t(x) \equiv \left(\begin{array}{c} a_T^{\frac{1}{\phi_A}} \left(a_H^{\frac{1}{\rho_A}} Q_{HA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} + (1 - a_H)^{\frac{1}{\rho_A}} Q_{FA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} \right)^{\frac{\rho_A}{\rho_A - 1} \frac{\phi_A - 1}{\phi_A}} \\ + (1 - a_T)^{\frac{1}{\phi_A}} Q_{NA,t}(x)^{\frac{\phi_A - 1}{\phi_A}} \end{array} \right)^{\frac{\phi_A}{\phi_A - 1}}$$

where Q_{HA}, Q_{FA} and Q_{NA} are bundles of respectively Home tradable, Foreign tradable and Home non-tradable intermediate goods, $\rho > 0$ is the elasticity of substitution between tradables and $\phi > 0$ is the elasticity of substitution between tradable and non-tradable goods. The parameter a_H $(0 < a_H < 1)$ is the weight of domestic tradable, a_T $(0 < a_T < 1)$ the weight of tradable goods.

The production of investment good is similar. There are symmetric Home firms under perfect competition indexed by $y \in (0, s]$, and symmetric Foreign firms by $y^* \in (s, 1]$. Output of Home firm y is:

$$E_t(y) \equiv \left(\begin{array}{c} v_T^{\frac{1}{\phi_E}} \left(v_H^{\frac{1}{\rho_E}} Q_{HE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} + (1 - v_H)^{\frac{1}{\rho_E}} Q_{FE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} \right)^{\frac{\rho_E}{\rho_E - 1} \frac{\phi_E - 1}{\phi_E}} \\ + (1 - v_T)^{\frac{1}{\phi_E}} Q_{NE,t}(y)^{\frac{\phi_E - 1}{\phi_E}} \end{array} \right)^{\frac{\phi_E}{\phi_E - 1}}$$

Finally, we assume that public expenditure C^g has the same composition as that of private consumption.

B Intermediate goods

B.1 Demand

Bundles used to produce the final consumption goods are CES indexes of differentiated intermediate goods, each produced by a single firm under conditions of monopolistic competition:

$$Q_{HA}(x) \equiv \left[\left(\frac{1}{s}\right)^{\theta_T} \int_0^s Q(h,x)^{\frac{\theta_T-1}{\theta_T}} dh\right]^{\frac{\theta_T}{\theta_T-1}} \tag{5}$$

$$Q_{FA}(x^*) \equiv \left[\left(\frac{1}{1-s}\right)^{\theta_T} \int_s^1 Q(f,x)^{\frac{\theta_T-1}{\theta_T}} df\right]^{\frac{\theta_T}{\theta_T-1}} \tag{6}$$

$$Q_{NA}(x) \equiv \left[\left(\frac{1}{s}\right)^{\theta_N} \int_0^s Q(n,x)^{\frac{\theta_N-1}{\theta_N}} dn\right]^{\frac{\theta_N}{\theta_T-1}} \tag{7}$$

where firms in the Home tradable and non-tradable intermediate sectors and in the Foreign intermediate tradable sector are respectively indexed by $h \in (0,s)$, $n \in (0,s)$, $f \in (s,1]$. Parameters θ_T, $\theta_N > 1$ are respectively the elasticity of substitution between brands in the tradable and non-tradable sector. The prices of the non-tradable intermediate goods are denoted $p(n)$. Each firm x takes these prices as given when minimizing production costs of the final good. The resulting demand for non-tradable intermediate input n is:

$$Q_{A,t}(n,x) = \left(\frac{1}{s}\right)\left(\frac{P_t(n)}{P_{N,t}}\right)^{-\theta_N} Q_{NA,t}(x) \tag{8}$$

where $P_{N,t}$ is the cost-minimizing price of one basket of local intermediates:

$$P_{N,t} = \left[\int_0^s P_t(n)^{1-\theta_N} dn\right]^{\frac{1}{1-\theta_N}} \tag{9}$$

We can derive $Q_A(h,x)$, $Q_A(f,x)$, $C_A^g(h,x)$, $C_A^g(f,x)$, P_H and P_F in a similar way. Firms y producing the final investment goods have similar demand curves. Aggregating over x and y, it can be shown that total demand for intermediate non-tradable good n is:

$$\int_0^s Q_{A,t}(n,x)\,dx + \int_0^s Q_{E,t}(n,y)\,dy + \int_0^s C_t^g(n,x)\,dx \tag{10}$$

$$= \left(\frac{P_t(n)}{P_{N,t}}\right)^{-\theta_N}\left(Q_{NA,t} + Q_{NE,t} + C_{N,t}^g\right) \tag{11}$$

where C_N^g is non-tradable component of the public sector consumption. Home demands for Home and Foreign tradable intermediate goods can be derived in a similar way.

B.2 Supply

The supply of each Home non-tradable intermediate good n is denoted by $N^S(n)$:

$$N_t^S(n) = \left((1-\alpha_N)^{\frac{1}{\xi_N}} L_{N,t}(n)^{\frac{\xi_N - 1}{\xi_N}} + \alpha^{\frac{1}{\xi_N}} K_{N,t}(n)^{\frac{\xi_N - 1}{\xi_N}} \right)^{\frac{\xi_N}{\xi_N - 1}} \tag{12}$$

Firm n uses labor $L_{N,t}^p(n)$ and capital $K_{N,t}(n)$ with constant elasticity of input substitution $\xi_N > 0$ and capital weight $0 < \alpha_N < 1$. Firms producing intermediate goods take the prices of labor inputs and capital as given. Denoting W_t the nominal wage index and R_t^K the nominal rental price of capital, cost minimization implies:

$$L_{N,t}^p(n) = (1-\alpha_N) \left(\frac{W_t}{MC_{N,t}(n)} \right)^{-\xi_N} N_t^S(n) \tag{13}$$

$$K_{N,t}(n) = \alpha \left(\frac{R_t^K}{MC_{N,t}(n)} \right)^{-\xi_N} N_t^S(n)$$

where $MC_{N,t}(n)$ is the nominal marginal cost:

$$MC_{N,t}(n) = \left((1-\alpha) W_t^{1-\xi_N} + \alpha \left(R_t^K \right)^{1-\xi_N} \right)^{\frac{1}{1-\xi_N}} \tag{14}$$

The productions of each Home tradable good, $T^S(h)$, is similarly characterized.

B.3 Price setting in the intermediate sector

Consider now profit maximization in the Home country's nontradable intermediate sector. Each firm n sets the price $p_t(n)$ by maximizing the present discounted value of profits subject to demand constraint (10) and the quadratic adjustment costs:

$$AC_{N,t}^p(n) \equiv \frac{\kappa_N^p}{2} \left(\frac{P_t(n)}{P_{t-1}(n)} - 1 \right)^2 Q_{N,t} \quad \kappa_N^p \geq 0$$

paid in unit of sectorial product $Q_{N,t}$ and where κ_N^p measures the degree of price stickiness. The resulting first-order condition, expressed in terms of domestic consumption, is:

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_t(n) - \frac{A_t(n)}{\theta_N - 1} \tag{15}$$

where $mc_t(n)$ is the real marginal cost and $A(n)$ contains terms related to the presence of price adjustment costs:

$$A_t(n) \approx \kappa_N^p \frac{P_t(n)}{P_{t-1}(n)} \left(\frac{P_t(n)}{P_{t-1}(n)} - 1 \right) \tag{16}$$

$$-\beta \kappa_N^p \frac{P_{t+1}(n)}{P_t(n)} \left(\frac{P_{t+1}(n)}{P_t(n)} - 1 \right) \frac{Q_{N,t+1}}{Q_{N,t}} \tag{17}$$

The above equations clarify the link between imperfect competition and nominal rigidities. As emphasized by Bayoumi et al.(2004), when the elasticity of substitution θ_N is very large and hence the competition in the sector is high, prices closely follow marginal costs, even though adjustment costs are large. To the contrary, it may be optimal to maintain stable prices and accommodate changes in demand through supply adjustments when the average markup over marginal costs is relatively high. If prices were flexible, optimal pricing would collapse to the standard pricing rule of constant markup over marginal costs (expressed in units of domestic consumption):

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_{N,t}(n) \tag{18}$$

Firms operating in the intermediate tradable sector solve a similar problem. We assume that there is market segmentation. Hence the firm producing the brand h chooses $p_t(h)$ in the Home market and $p_t^*(h)$ in the Foreign market as to maximize the expected flow of profits (in terms of domestic consumption units):

$$E_t \sum_{\tau=t}^{\infty} \Lambda_{t,\tau} \left[p_\tau(h) y_\tau(h) + p_\tau^*(h) y_\tau^*(h) - mc_{H,\tau}(h) \left(y_\tau(h) + y_\tau^*(h) \right) \right]$$

subject to quadratic price adjustment costs similar to those considered for nontradables and standard demand constraints. The term E_t denotes the expectation operator conditional on the information set at time t, $\Lambda_{t,\tau}$ is the appropriate discount rate and $mc_{H,t}(h)$ is the real marginal cost. The first order conditions with respect to $p_t(h)$ and $p_t^*(h)$ are:

$$p_t(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t(h)}{\theta_T - 1} \tag{19}$$

$$p_t^*(h) = \frac{\theta_T^*}{\theta_T - 1} mc_t(h) - \frac{A_t^*(h)}{\theta_T - 1} \tag{20}$$

where θ_T^* is the elasticity of substitution of tradable intermediate goods in the Foreign country, while $A(h)$ and $A^*(h)$ involve terms related to the presence of price adjustment costs:

$$A_t(h) \approx \kappa_H^p \frac{P_t(h)}{P_{t-1}(h)} \left(\frac{P_t(h)}{P_{t-1}(h)} - 1 \right) \tag{21}$$

$$-\beta \kappa_H^p \frac{P_{t+1}(h)}{P_t(h)} \left(\frac{P_{t+1}(h)}{P_t(h)} - 1 \right) \frac{Q_{H,t+1}}{Q_{H,t}} \tag{22}$$

$$A_t^*(h) \approx \theta_T{}^* - 1 + \kappa_H^p{}^* \frac{P_t^*(h)}{P_{t-1}^*(h)} \left(\frac{P_t^*(h)}{P_{t-1}^*(h)} - 1 \right) \tag{23}$$

$$-\beta \kappa_H^p{}^* \frac{P_{t+1}^*(h)}{P_t^*(h)} \left(\frac{P_{t+1}^*(h)}{P_t^*(h)} - 1 \right) \frac{Q_{H,t+1}^*}{Q_{H,t}^*} \tag{24}$$

where $\kappa_H^p > 0$ ($\kappa_H^p{}^* > 0$) measure the degree of nominal rigidity in the Home (Foreign) country. If nominal rigidities in the (domestic) export market are highly relevant (that is, if is relatively large), the degree of inertia of Home goods prices in the Foreign market will be high. If prices were flexible ($\kappa_H^p = \kappa_H^p{}^*$) and $\theta_T = \theta_T^*$, then optimal price setting would be consistent with the cross-border law of one price:

$$p_t(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) = p_t^*(h) \tag{25}$$

B.4 Labor Market

In the case of firms in the nontradable intermediate sector, the labor input $L_N(n)$ is a CES combination of differentiated labor inputs supplied by domestic agents and defined over a continuum of mass equal to the country size ($j \in [0, s]$):

$$L_{N,t}(n) \equiv \left(\frac{1}{s} \right)^{\frac{1}{\psi}} \left[\int_0^s L_t(n,j)^{\frac{\psi-1}{\psi}} dj \right]^{\frac{\psi}{\psi-1}} \tag{26}$$

where $L(n,j)$ is the demand of the labor input of type j by the producer of good n and $\psi > 1$ is the elasticity of substitution among labor inputs. Cost minimization implies:

$$L_t^p(n,j) = \left(\frac{1}{s} \right) \left(\frac{W_t(j)}{W_t} \right)^{-\psi} L_{N,t}^p(j), \tag{27}$$

where $W(j)$ is the nominal wage of labor input j and the wage index W is:

$$W_t = \left[\left(\frac{1}{s} \right) \int_0^s W_t(h)^{1-\psi} dj \right]^{\frac{1}{1-\psi}}. \tag{28}$$

Similar equations hold for firms producing intermediate tradable goods. Each household is the monopolistic supplier of a labor input j and sets

the nominal wage facing a downward-sloping demand, obtained by aggregating demand across Home firms. The wage adjustment is sluggish because of quadratic costs paid in terms of the total wage bill:

$$AC_t^W = \frac{\kappa_W}{2}\left(\frac{W_t}{W_{t-1}} - 1\right)^2 W_t L_t \tag{29}$$

where the parameter $\kappa_W > 0$ measures the degree of nominal wage rigidity and L is the total amount of labor in the Home economy.

B Monetary Policy

The monetary authority controls the short-term rate according to a Taylor rule of the form:

$$\left(\frac{1+i_t}{1+i}\right) = \left(\frac{1+i_t}{1+i}\right)^{\rho_i} \left(\Pi_{MU,t}\right)^{(1-\rho_i)\rho_\pi} \left(\frac{GDP_{MU,t}}{GDP_{MU,t-1}}\right)^{(1-\rho_i)\rho_{GDP}} \tag{30}$$

The parameter ρ_i $(0 < \rho_i < 1)$ captures inertia in interest rate setting, while parameters ρ_π and ρ_{GDP} are respectively the weights of currency union's CPI inflation rate $\Pi_{MU,t}$ and GDP $GDP_{MU,t}$. The CPI inflation rate is a geometric average of CPI inflation rates in the Home and Foreign country (respectively Π_t and Π_t^*) with weights equal to the correspondent country size:

$$\Pi_{MU,t} \equiv \left(\Pi_t\right)^s \left(\Pi_t^*\right)^{1-s} \tag{31}$$

The union-wide GDP is the sum of the Home and Foreign GDPs (respectively GDP_t and GDP_t^*), both evaluated at the steady state prices:

$$GDP_{MU,t} \equiv GDP_t + rer * GDP_t^* \tag{32}$$

where rer is the Home real exchange rate, defined as the ratio of rest of the euro area to Home consumer prices.

C Market Clearing

The model is closed by imposing the following resource constraints and market clearing conditions. The resource constraint for Home nontradable final consumption good is:

$$\int_0^s A_t\left(x\right) dx \geq \int_0^s C_t\left(j\right) dj + C_t^g \tag{33}$$

The resource constraint for Home nontradable final investment good is:

$$\int_0^s E_t\left(x\right) dx \geq \int_0^s I_t\left(j\right) dj \tag{34}$$

The resource constraint for good n is

$$N_t^S(n) \geq \int_0^s Q_t(n,x)\,dx \tag{35}$$

The Home tradable h can be used by Home firms or imported by Foreign firms:

$$T_t^S(h) \geq \int_0^s Q_t(h,x)\,dx + \int_s^1 Q_t(h,x^*)\,dx^* \tag{36}$$

The resource constraints for factor market are:

$$\int_0^s L_t(j)\,dj \geq \int_0^s L_t(n)\,dn + \int_0^s L_t(h)\,dh + L_t^g \tag{37}$$

$$\int_0^s K_{t-1}(j)\,dj \geq \int_0^s K_t(n)\,dn + \int_0^s K_t(h)\,dh \tag{38}$$

The bond market clearing condition is:

$$\int_0^s B_t(j)\,dj + \int_s^1 B_t(j^*)\,dj^* + B_t^g + B_t^{g,*} = 0 \tag{39}$$

D The equilibrium

We find a symmetric equilibrium of the model. In each country there is a representative agent and four representative sectorial firms (in the intermediate tradable sector, intermediate nontradable sector, consumption production sector and investment production sector). The equilibrium is a sequence of allocations and prices such that, given initial conditions and the sequence of exogenous shocks, each private agent and firm satisfy the correspondent first order conditions, the private and public sector budget constraints and market clearing conditions for goods, labor, capital and bond holdings.

Table 1. Parametrization of Germany, Belgium and the Rest of the Euro Area
(Base-Case Parameters)

Parameter	Germany	Belgium	Rest of the euro area
Rate of time preference $\left(1/\beta^4 - 1\right) * 100$	5.00	5.00	5.00
Intertemporal elasticity of substitution $1/\sigma$	1.00	1.00	1.00
Frisch elasticity of labor $1/\left(\tau - 1\right)$	2.00	2.00	2.00
Depreciation rate of (private and public) capital δ, δ^*	0.025	0.025	0.025
Elasticity of substitution between private and public goods θ	1.50	1.50	1.50
Bias towards public goods $1 - \omega$	0.20	0.20	0.20
Tradable Intermediate Goods			
El. of substitution btw factors of production ξ_T, ξ_T^*	0.85	0.85	0.90
Bias towards capital α_T, α_T^*	0.75	0.75	0.70
Nontradable Intermediate Goods			
El. of substitution btw factors of production ξ_N, ξ_N^*	0.79	0.79	0.95
Bias towards capital α_N	0.70	0.70	0.70
Production function of the public good			
El. of substitution btw factors of production α_g	0.79	0.79	0.95
Bias towards intermediate goods $\gamma_{C^g}, \gamma_{C^g}^*$	0.15	0.15	0.15
Bias towards public employment $\gamma_{L^g}, \gamma_{L^g}^*$	0.15	0.15	0.15
Final consumption goods			
Substitution btw domestic and imported tradables ϕ_A, ϕ_A^*	1.50	1.50	1.50
Bias towards domestic tradables a_H, a_F^*	0.60	0.30	0.70 (0.97)
Substitution between tradables and nontradables ρ_A	0.50	0.50	0.50
Bias towards tradable goods a_T, a_T^*	0.55	0.80	0.50
Final investment goods			
Substitution btw domestic and imported tradables ϕ_E	1.50	1.50	1.50
Bias towards domestic tradables υ_H, υ_F^*	0.30	0.30	0.70 (0.97)
Substitution btw tradables and nontradables ρ	0.50	0.50	0.50
Bias towards tradable goods υ_T, υ_T^*	0.55	0.80	0.50
Size n and $(1 - n)$	0.30	0.03	0.70 (0.97)

Note: between brackets, values for rest of the euro area parameters specific to the Belgium-rest of the euro area model.

Table 2. Gross Markups

	Markups (Implied Elasticities of Substitution)		
	Tradables	Non-tradables	Wages
Germany	1.2 (θ_T=6.0)	1.3 (θ_N=4.3)	1.3 (ψ=4.3)
Belgium	1.2 (θ_T=6.0)	1.3 (θ_N=4.3)	1.3 (ψ=4.3)
Rest of the euro area	1.2 (θ_T^*=6.0)	1.2 (θ_N^*=4.3)	1.2 (ψ^*=4.3)

Note: between brackets, the elasticity of substitution between brands/labor varieties consistent with the markup value

Table 3. Real and Nominal Adjustment Costs (Base-Case Parameters)

Parameter ("*" refers to rest of the euro area)	Germany	Belgium	Rest of the euro area
Real Adjustment Costs			
Investment ϕ_I, ϕ_I^*	3.50	3.50	3.50
Households' financial net position parameter ϕ_{b1}	0.01	0.01	-
Households' financial net position parameter ϕ_{b2}	0.01	0.01	-
Nominal Adjustment Costs			
Wages κ_W, κ_W^*	150	150	150
Price of nontradables κ_N, κ_N^*	200	200	200
Domestic price of tradables κ_H, k_F^*	200	200	200
Price of imported tradables κ_F, κ_H^*	200	200	200

Table 4. Fiscal and Monetary Policy Rules

Parameter	Germany	Belgium	Rest of the euro area	Euro Area
Regional fiscal policy rule				
Deviation of public debt from target ϕ_1, ϕ_1^*	± 0.5	± 0.5	± 0.5	-
Public deficit ϕ_2, ϕ_2^*	± 5.0	± 5.0	± 5.0	
GDP growth ϕ_3, ϕ_3^*	± 5.0	± 5.0	± 5.0	-
Common monetary policy rule	-	-		
Lagged interest rate at $t-1$ ρ_i	-	-		0.9
Inflation ρ_Π	-	-		1.7
GDP growth ρ_{GDP}	-	-		0.4

Table 5. Great Ratios and tax rates

(Base-Case Parameters)

	Germany		Belgium		Rest of the euro area	
	data	model	data	model	data	model
MACRO VARIABLES						
Private consumption C	55	56	53	55	57	56
Private Investment I	20	20	21	22	22	21
Export	20	20	52	47	-	-
Imports	17	20	50	47	-	-
Net Foreign Asset Position	0	0	0	0	-	-
FISCAL VARIABLES						
Public purchases C^g	11	11	11	11	10	10
Transfer to households Tr	17	11	15	12	16	12
Wage bill WL^g	7	11	12	11	10	11
Public Investment I^g	2	2	2	2	3	3
Interests	3	3	4	4	3	3.0
Debt (ratio to annual GDP)	65	65	85	85	60	60
Tax Rates						
on wage	39	39	42	42	34	34
on rental rate of capital	21	21	20	20	23	23
on price of consumption	20	20	22	22	22	22

Data sources: National Account data for macroeconomic variables (2008 values).

For fiscal variables: expenditure data (2008 values) are from AMECO database. Tax rates (in percent) are taken from Eurostat (2008). Macro and fiscal variables are expressed as a ratio to GDP.

Table 6. Steady state comparisons: reduction in tax and expenditure distortions (% changes)

	Tax distortions (1% of GDP)			Expenditure distortions (1% of GDP)	
	$[Tr, \tau^{\ell}]$ (1)	$[Tr, \tau^{k}]$ (2)	$[Tr, \tau^{c}]$ (3)	$[Tr, C^{g}]$ (4)	$[Tr, L^{g}]$ (5)
Germany					
GDP	1.7	2.2	0.5	-0.6	-0.5
Private consumption (C)	2.1	1.5	0.7	0.9	0.8
Public good (Y_g)	0.2	0.3	0.1	-1.3	-2.6
Investment	1.9	4.1	0.6	-0.7	0.5
Export	0.2	0.3	0.1	-0.1	0.1
Import	2.1	2.8	0.7	-0.8	0.6
Hours worked (L)	2.1	0.6	0.7	-0.8	-1.8
Real wage (w)	-0.9	1.7	-0.3	0.3	-0.3
After-tax real wage ($(1-\tau^{\ell})w$)	3.1	1.7	-0.3	0.3	-0.3
Terms of trade (+=deterioration)	1.4	1.8	0.4	-0.5	0.4
Real exchange rate (+=depreciation)	0.9	1.0	0.3	-0.3	0.3
Welfare	1.2	1.1	0.4	0.7	0.6
Rest of the euro area					
GDP	0.6	0.7	0.2	-0.2	0.2
Private Consumption (C^*)	0.6	0.8	0.2	-0.2	0.2

Table 7a. Steady state comparisons (%changes)

	No change in expenditures		No change in tax rates			Reduction in labor tax rate			Reduction in capital tax rate			Reduction in both tax rates		
	$[B,\tau^{\ell}]$	$[B,\tau_k]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Germany														
GDP	1.2	1.1	0.3	0.3	0.0	2.9	3.0	3.5	4.6	4.9	6.2	7.3	7.9	9.9
Private consumption (C)	1.5	0.7	-0.4	-0.4	0.0	5.1	5.0	4.2	6.3	6.2	4.1	12.2	12.0	8.5
Public good (Y_g)	0.2	0.2	0.6	1.2	0.0	-0.8	-2.1	0.5	-2.4	-6.0	0.8	-4.4	-11.0	1.3
Investment	1.4	2.0	0.4	-0.3	0.0	3.2	4.4	3.9	10.0	13.3	11.8	13.1	18.6	16.1
Export	0.2	0.2	0.0	0.0	0.0	0.4	0.5	0.5	0.7	1.0	0.9	1.0	1.6	1.4
Import	1.5	1.4	0.4	-0.3	0.0	3.5	4.9	4.3	5.9	9.4	7.9	9.2	15.2	12.5
Hours worked (L)	1.5	0.3	0.4	0.9	0.0	3.6	2.6	4.3	-0.3	-2.9	1.6	2.8	-1.2	6.0
Real wage (w)	-0.7	0.8	-0.2	0.2	0.0	-1.5	-2.1	-1.8	5.6	3.9	4.7	4.2	1.5	2.8
After-tax real wage ($(1-\tau^{\ell})w$)	2.2	0.8	-0.2	0.2	0.0	6.6	5.9	6.2	5.6	3.9	4.7	12.7	9.8	11.3
Terms of trade (+=deterioration)	1.0	0.9	0.3	-0.2	0.0	2.3	3.2	2.8	3.8	6.1	5.1	6.0	9.7	8.1
Real exch. rate (+=depreciation)	0.7	0.5	0.2	-0.1	0.0	1.5	2.1	1.9	2.0	3.5	2.8	3.4	5.8	4.8
Welfare	0.9	0.6	-0.3	-0.3	0.0	3.1	3.0	2.5	4.7	4.6	3.1	8.3	7.8	5.7
Rest of the euro area														
GDP	0.4	0.4	0.1	-0.1	0.0	1.0	1.3	1.2	1.6	2.5	2.1	2.4	3.9	3.3
Private Consumption (C^*)	0.4	0.4	0.1	-0.1	0.0	1.0	1.3	1.2	1.6	2.5	2.1	2.5	4.0	3.3

Table 7b. Steady state comparisons (%changes)

	No change in expenditures		No change in tax rates			Reduction in labor tax rate			Reduction in capital tax rate			Reduction in both tax rates		
	$[B,\tau^{\ell}]$	$[B,\tau_k]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$	$[B,C^g]$	$[B,L^g]$	$[B,Tr]$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Belgium														
GDP	0.8	0.7	0.2	0.4	0.0	1.7	1.4	2.1	3.3	2.3	4.2	4.9	3.5	6.5
Private consumption (C)	1.0	0.4	-0.6	-0.3	0.0	3.9	3.4	2.8	4.9	3.6	2.1	9.6	7.5	5.0
Public good (Y_g)	0.1	0.1	0.7	1.5	0.0	-1.0	-2.6	0.3	-2.9	-7.7	0.7	-5.2	-13.7	1.0
Investment	1.1	1.8	0.3	-0.2	0.0	2.4	3.3	2.9	9.1	11.6	10.5	11.5	15.5	13.8
Export	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2
Import	1.4	1.1	0.4	-0.2	0.0	3.3	4.4	4.0	4.7	7.9	6.5	7.8	13.0	10.7
Hours worked (L)	1.6	0.3	0.4	1.0	0.0	3.7	2.7	4.5	-0.4	-3.3	1.5	2.9	-1.6	6.1
Real wage (w)	-1.3	0.5	-0.3	0.3	0.0	-2.8	-3.9	-3.4	4.3	1.4	2.8	1.7	-2.8	-0.7
After-tax real wage ($(1-\tau^{\ell})w$)	1.8	0.5	-0.3	0.3	0.0	5.6	4.5	5.0	4.3	1.4	2.8	10.5	5.6	7.9
Terms of trade (+=deterioration)	1.0	0.7	0.2	-0.2	0.0	2.2	2.9	2.6	3.1	5.2	4.3	5.1	8.5	7.0
Real exch. rate (+=depreciation)	0.5	0.3	0.1	-0.1	0.0	1.0	1.4	1.2	1.2	2.2	1.8	2.1	3.7	3.0
Welfare	0.5	0.3	-0.5	-0.3	0.0	2.4	1.9	1.4	3.9	2.8	1.5	6.8	4.8	3.0
Rest of the euro area														
GDP	0.1	0.1	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.4	0.3	0.4	0.6	0.5
Private Consumption (C^*)	0.1	0.1	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.4	0.3	0.4	0.6	0.5

Table 8. Welfare (% changes)

		Germany	Belgium
No change in expenditures	$[B, \tau^{\ell}]$	-0.2	0.0
	$[B, \tau^{k}]$	0.0	0.0
No change in tax rates	$[B, C^{g}]$	-0.1	0.0
	$[B, L^{g}]$	-0.1	0.0
	$[B, Tr]$	0.0	0.0
Reduction in labor tax rate	$[B, C^{g}]$	2.8	2.2
	$[B, L^{g}]$	2.0	1.4
	$[B, Tr]$	1.5	0.8
Reduction in capital tax rate	$[B, C^{g}]$	2.0	2.6
	$[B, L^{g}]$	1.3	1.0
	$[B, Tr]$	0.7	-0.1
Reduction in both tax rates	$[B, C^{g}]$	4.7	4.8
	$[B, L^{g}]$	3.1	1.9
	$[B, Tr]$	2.2	0.7

Table 9. Robustness, steady state comparisons(% changes)

	Baseline			Belgian openness			Belgian openness and size		
	$[B, C^g]$	$[B, L^g]$	$[B, Tr]$	$[B, C^g]$	$[B, L^g]$	$[B, Tr]$	$[B, C^g]$	$[B, L^g]$	$[B, Tr]$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Germany									
GDP	7.3	7.9	9.9	6.3	5.6	8.1	4.9	3.5	6.4
Private consumption (C)	12.2	12.0	8.5	11.2	9.4	6.4	9.6	7.3	4.9
Public good (Y_g)	-4.4	-11.0	1.3	-5.0	-11.2	1.2	-5.3	-14.3	1.0
Investment	13.1	18.6	16.1	13.1	17.8	15.6	11.5	15.5	13.8
Export	1.0	1.6	1.4	0.3	0.4	0.4	0.1	0.2	0.2
Import	9.2	15.2	12.5	8.5	13.8	11.3	7.6	12.8	10.6
Hours worked (L)	2.8	-1.2	6.0	3.0	-1.7	6.1	2.7	-1.7	5.9
Real wage (w)	4.2	1.5	2.8	3.0	-1.4	0.8	2.0	-2.6	-0.4
After-tax real wage ($(1-\tau^{\ell})w$)	12.7	9.8	11.3	11.4	6.7	9.1	10.3	5.4	7.7
Terms of trade (+=deterioration)	6.0	9.7	8.1	5.6	9.0	7.4	5.0	8.4	6.9
Real exch. rate (+=depreciation)	3.4	5.8	4.8	2.6	4.3	3.5	2.1	3.6	3.0
Welfare: steady state	8.3	7.8	5.7	6.4	4.5	3.7	6.8	4.6	2.8
Welfare: with transition	5.5	3.7	2.4	4.0	1.2	1.1	4.8	1.9	0.6
Rest of the euro area									
GDP	2.4	3.9	2.0	0.6	1.0	0.8	0.3	0.6	0.5
Private Consumption (C^*)	2.5	4	2.0	0.7	1.0	0.9	0.4	0.6	0.5

Table 10. Robustness, steady state comparisons(% changes)

	Baseline			$\tau = 3$			$\omega = 0.5$			$\theta = 0.8$		
	$[B, C^g]$	$[B, L^g]$	$[B, Tr]$	$[B, C^g]$	$[B, L^g]$	$[B, Tr]$	$[B, C^g]$	$[B, L^g]$	$[B, Tr]$	$[B, C^g]$	$[B, L^g]$	$[B, Tr]$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Germany												
GDP	7.3	7.9	9.9	6.1	7.8	7.6	7.8	8.4	10.1	6.3	6.5	9.5
Private consumption (C)	12.2	12.0	8.5	10.7	11.5	5.6	12.9	12.7	9.0	11.3	10.6	8.0
Public good (Y_g)	-4.4	-11.0	1.3	-4.7	-21.4	1.0	-4.2	-8.1	1.4	-4.7	-11.2	1.3
Investment	13.1	18.6	16.1	11.7	18.2	13.2	13.8	19.3	16.5	12.0	17.2	15.6
Export	1.0	1.6	1.4	0.8	1.5	1.0	1.2	1.9	1.6	0.8	1.3	1.1
Import	9.2	15.2	12.5	7.7	14.7	9.4	10.0	15.8	12.9	8.0	13.7	12.0
Hours worked (L)	2.8	-1.2	6.0	1.6	-1.6	3.4	3.3	-0.4	6.0	1.7	-2.9	5.5
Real wage (w)	4.2	1.5	2.8	4.8	1.6	4.1	3.9	1.3	2.7	4.6	1.9	2.9
After-tax real wage ($(1-\tau^{\ell})w$)	12.7	9.8	11.3	13.4	10.0	12.6	12.4	9.6	11.2	13.2	10.3	11.4
Terms of trade (+=deterioration)	6.0	9.7	8.1	5.0	9.3	6.1	6.3	10.0	8.2	5.3	9.0	7.9
Real exch. rate (+=depreciation)	3.4	5.8	4.8	2.8	5.4	3.5	3.6	6.0	4.9	3.0	5.4	4.7
Welfare: steady state	8.3	7.8	5.7	7.7	6.3	4.0	5.5	4.5	4.8	7.2	6.2	5.2
Welfare: with transition	5.5	3.7	2.4	5.2	2.0	1.4	3.1	1.1	2.2	4.7	2.1	2.3
Rest of the euro area												
GDP	2.4	3.9	2.0	2.0	3.7	2.4	2.7	4.2	3.5	2.0	3.4	3.0
Private Consumption (C^*)	2.5	4	2.0	2.0	3.8	2.5	2.8	4.3	3.6	2.0	3.4	3.0

Figure 1. Welfare (% deviation from steady state), compensating the tax cuts with different expenditure items

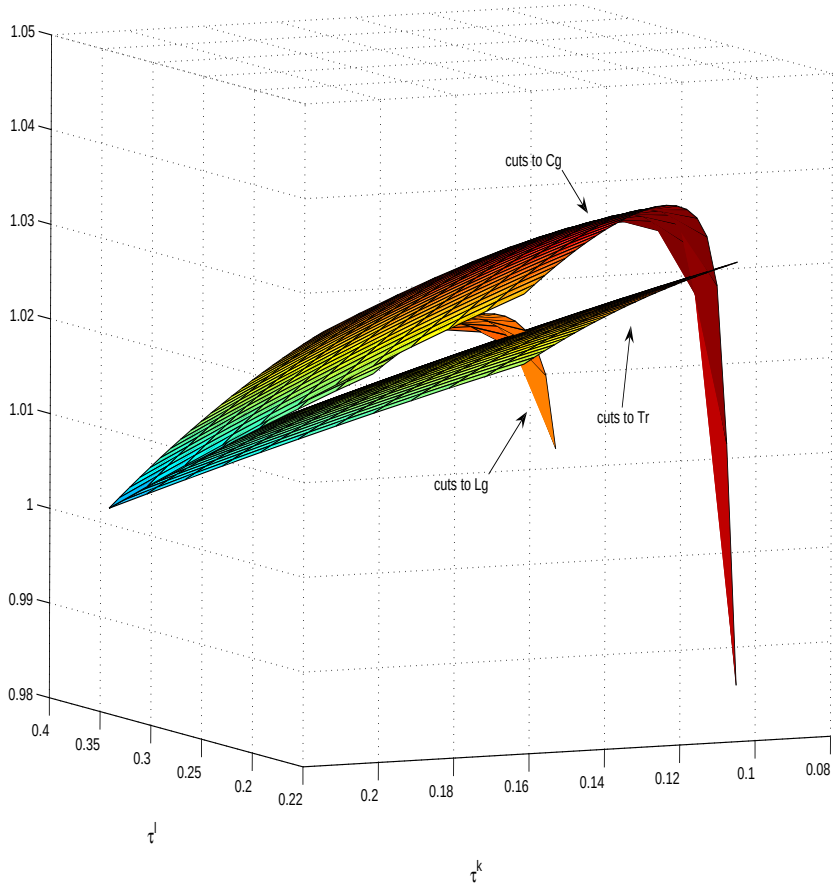

Figure 2. Baseline scenario: fiscal variables

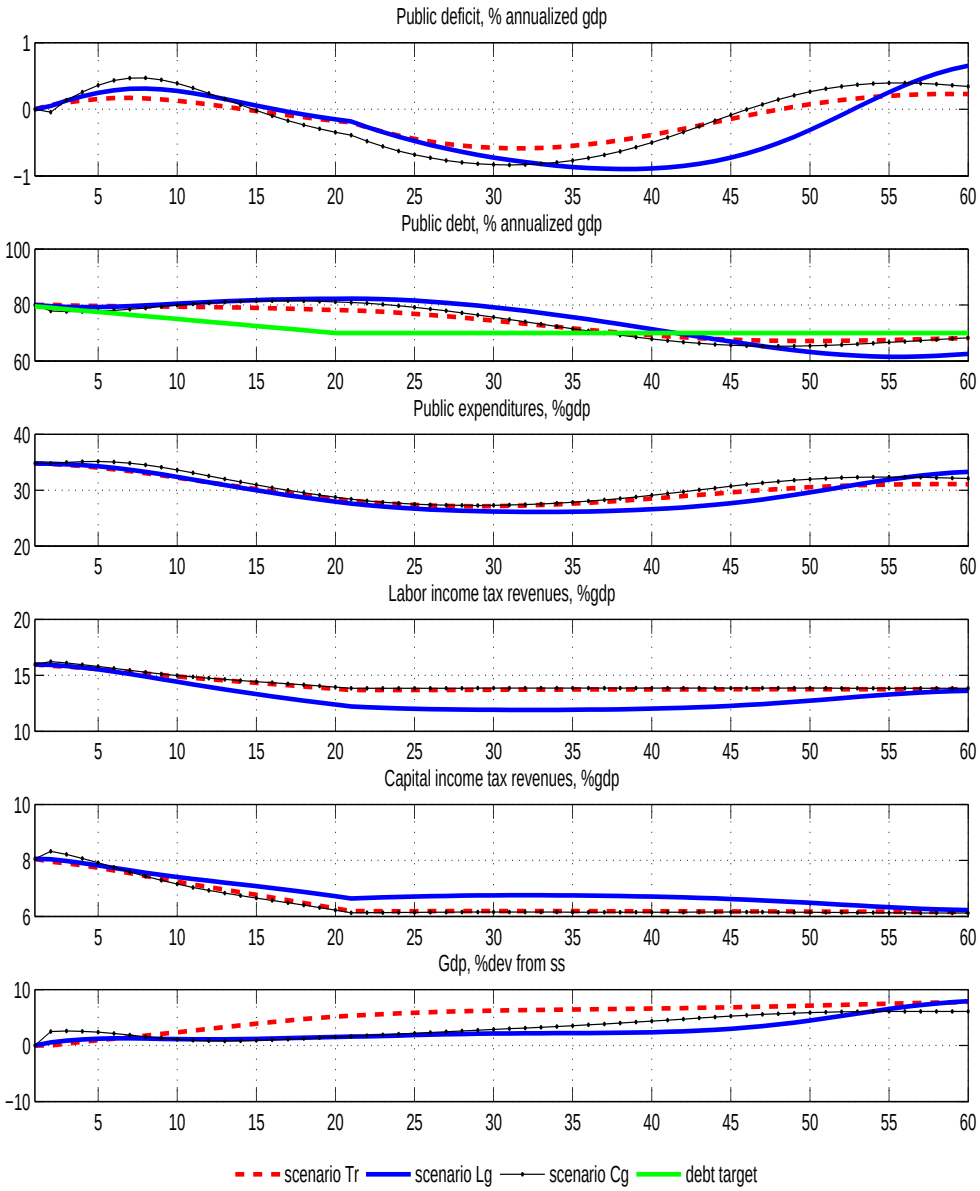

Figure 3. Baseline scenario: macroeconomic variables