Budget-Neutral Labor Tax Wedge Reductions: A Simulation-Based Analysis for the Euro Area*

Maria-Grazia Attinasi,[a] Doris Prammer,[b] Nikolai Stähler,[c] Martino Tasso,[d] and Stefan van Parys[e]

[a]European Central Bank
[b]Oesterreichische Nationalbank
[c]Deutsche Bundesbank
[d]Banca d'Italia
[e]National Bank of Belgium

Budget-neutral tax wedge reductions rank high in the policy agenda of several EMU member states. Using a New Keynesian DSGE model of a monetary union with a search-and-matching market structure and a fiscal bloc containing a wide range of taxes and disaggregated government spending, we evaluate the macroeconomic and welfare effects of reducing the firms' and workers' labor tax rates under alternative financing instruments. Overall, a tax wedge reduction is beneficial in terms of both welfare and output. While financing the labor tax wedge reduction by an increase in consumption taxation yields most favorable output effects, financing it by a reduction in government spending is more welfare enhancing, as the latter does not imply a policy-induced increase in private consumption costs. We also show that, when there exists an extensive and intensive labor margin, a reduction in the workers' and not the firms' burden can be most beneficial.

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1. Introduction

In most euro-area countries, the tax wedge on labor income is large relative to international standards (European Commission 2014). Since 2011, the European Commission's country-specific recommendations include calls for reducing the tax wedge. In July 2014, the Eurogroup identified lowering labor taxes as a top policy priority. Moreover, given the lack of fiscal space in many member countries, it was recommended that such reforms should be implemented in a budget-neutral way. The issue is again addressed in a recent publication (European Commission 2016). Furthermore, given the weak labor market performance in the aftermath of the crisis and the fact that, within the euro zone, about 18 million people are unemployed (yielding an average unemployment rate of 11 percent),[1] it is even claimed that "the crisis will only be over when unemployment falls to socially sustainable levels" and that "jobs fail to be created . . . not because of the 'lack of demand' as often claimed, but mainly because wage costs are high relative to productivity [and] social insurance and tax burdens are heavy" (Thimann 2015).

This paper analyzes the macroeconomic and welfare effects of a budget-neutral reduction in the labor tax wedge. We use a macroeconomic New Keynesian dynamic stochastic general equilibrium (DSGE) model of a monetary union with a search-and-matching labor market and a fiscal bloc containing a wide range of taxes and government spending. The model-based framework allows analysis of the issue at hand from different angles. First, we explore how different ways of achieving budget neutrality (e.g., higher consumption taxes versus lower government spending or employment) affect the economy. Second, we assess whether cutting social security contributions or personal income taxes matters for these effects, especially in the presence of an intensive labor margin on top of the extensive one. Finally, we test for the role of country-specific characteristics (e.g., trade openness, overall labor market efficiency, and country size).

[1] See http://ec.europa.eu/eurostat/statistics-explained/index.php/Unemployment_statistics# Unemployment_trends.

To the best of our knowledge, this is the first paper to model the effects of a budget-neutral reduction in the labor tax wedge in the context of a search-and-matching labor market including an extensive (i.e., whether to hire a new worker or not) and intensive (i.e., deciding how many hours to work) labor adjustment margin. This labor market structure allows for a better understanding of how cuts in social security contributions or personal income taxes affect labor demand and supply, along with the role of structural labor market features (for example, the bargaining process).

A budget-neutral reduction in the labor tax wedge is found to have positive macroeconomic effects. The larger gains are associated with a fiscal devaluation—that is, a cut in the tax wedge financed by an increase in consumption taxes as defined in Engler et al. (2017)[2]—as opposed to a reduction in government purchases as a means to finance a lower tax wedge. This is because in our model government purchases contain a full home bias, while part of private demand is spent on imported goods. Hence, the increase in private demand stemming from a higher net labor income cannot fully compensate for the decline in aggregate demand (caused by the cut in government purchases). Findings are reversed in terms of households' welfare. Unlike a fiscal devaluation, decreasing public purchases does not depress private consumption via the policy-induced increase in consumption costs.

When an intensive labor margin is included in the model (i.e., firms and workers bargain over both wages and hours), financing a tax wedge cut via lower income taxes yields higher output gains than cutting firms' social security contributions. The reason is that lower income taxes immediately translate into higher net wages, hence

[2]In a strict sense, fiscal devaluation is defined as an intended nominal devaluation that can be robustly replicated with a small set of fiscal instruments: lower labor income taxes financed by a higher value-added tax (VAT) rate, where there is a sequence of taxes that replicates a sequence of nominal exchange rates while leaving the labor tax wedge constant (see Farhi, Gopinath, and Itskhoki 2014 and Kaufmann 2016). The literature, which we discuss in more detail below, however, also defines a permanent shift from labor income taxes to consumption taxes, where the latter is typically used as a proxy for VAT in New Keynesian models, as fiscal devaluation. We follow this definition in the paper. Also considering the similarities between a VAT and a generic consumption tax, qualitatively our results should be unaffected by this choice.

generating a higher disposable income. Firms, on their side, have an incentive to adjust labor input via the intensive margin rather than hiring new workers, as they save on search costs. Hiring new workers becomes more attractive when firms' tax burden is reduced (i.e., the cut in the tax wedge is implemented via lower social security contributions). In this case, the increase in workers' net wage income is relatively lower, as it is only indirectly affected by the measure. Workers are then less willing to supply more hours of work, which firms partly compensate for by increasing job creation. The additional search costs lead to a smaller increase in available net income so that the increase in private consumption is smaller than a reduction in the personal income tax. It should be noted that in the absence of an intensive labor margin (i.e., when hours worked are kept at the initial steady-state value), our model predicts that a cut in social security contributions yields higher output gains than a cut in the personal income tax, as the direct reduction in labor costs leads to a stronger fall in unemployment.

We find that country-specific characteristics matter for the model results in quantitative terms, but not qualitatively. Furthermore, spillovers to the rest of the euro area are positive, small, and depend on country size.

The rest of the paper is organized as follows. In section 2, we discuss related literature. Section 3 describes the model and its calibration. In section 4, we present the simulation design, while section 5 discusses the results. A welfare assessment can be found in section 6. Section 7 concludes.

2. Related Literature

The impact of taxes on the labor market has been addressed from several angles in the economic literature. Empirical macroeconomic studies mostly use aggregate data and perform cross-country comparisons and, in line with microeconomic theory (see Meghir and Phillips 2010, and Keane 2011), they usually find harmful effects of tax wedges on employment (e.g., Daveri and Tabellini 2000, and Bassanini and Duval 2006). By calibrating a simple labor supply model to the features of the United States and the main European economies, Prescott (2004) finds that the differences in aggregated hours of work across the Atlantic are primarily driven by observed discrepancies in marginal effective tax rates.[3]

Coenen, McAdam, and Straub (2008) analyze Prescott's insight through the lenses of a DSGE model. They find that reducing European tax wedges to levels comparable to the ones prevailing in the United States would increase the number of total hours worked by about 10 percent and significantly boost GDP in the long run. Ohanian, Raffo, and Rogerson (2008), using the framework of a neoclassical growth model calibrated to the economies of OECD countries over 1956–2004, also find that changes in tax rates explain most of the variability in worked hours across countries and through time.

Reductions in the labor tax wedge financed by higher consumption taxation have recently also been discussed with a focus on international competitiveness, often referred to as fiscal devaluation. Farhi, Gopinath, and Itskhoki (2014) provide a formal analysis of fiscal devaluations in a New Keynesian open economy DSGE model. They find that an intended nominal devaluation can be robustly replicated with a small set of fiscal instruments (namely labor income and consumption taxes). However, their contribution also shows that one should not over-estimate fiscal devaluation as a policy tool, as it may require substantial changes in tax rates. For example, a 10 percent nominal devaluation in Spain would require an increase of VAT taxes of as much as 7.6 percentage points.

Gadatsch, Stähler, and Weigert (2016) show that Germany's fiscal devaluation from 1999 to 2003 (generating a decrease in effective labor taxation by about 2 percentage points) improved GDP by only about one-quarter percentage point. Similarly, Lipinska and von Thadden (2009) show in a two-country DSGE model with a Walrasian labor market without matching frictions that fiscal devaluations generate only small quantitative effects. Stähler and Thomas (2012) and Boscá, Doménech, and Ferri (2013) show positive effects of fiscal devaluation in Spain. The positive effect of a fiscal devaluation is also confirmed by Gomes, Jacquinot, and Pisani (2016),

[3]This paper spurred a long series of reactions. Alesina, Glaeser, and Sacerdote (2006) present a critical evaluation of Prescott's argument. Even though the authors recognize the importance of taxes, they consider other labor market institutions more relevant. Empirically, Nickell, Nunziata, and Ochel (2005) discuss this issue for OECD countries.

who include Portugal in their analysis, and CPB (2013), the latter using country-specific general equilibrium models for four euro-area countries. Using the multi-country version of the Commission's QUEST model, the European Commission (2013) shows that fiscal devaluation mildly affects GDP positively already in the short to medium run, and can indeed significantly increase GDP in the long run. They also compare targeted tax reductions for differently skilled workers and find that cutting labor income tax rates for low-skilled (and, therefore, low-wage-earning) workers further augments GDP improvements because these workers exhibit a higher labor supply elasticity. Langot, Patureau, and Sopraseuth (2014) also find beneficial effects of fiscal devaluation in a model-based analysis for France.

The existing literature on fiscal devaluation usually focuses on one type of fiscal devaluation, i.e., either a reduction in employees' labor taxation or a reduction in employers' social security contribution. Notable exceptions are Burgert and Roeger (2014) and Engler et al. (2017). Engler et al. (2017) show that if only employers' social security contributions are decreased (instead of employees' and employers' contributions or labor taxes per se as done in the similar model by Lipinska and von Thadden 2009), the expected effects can be somewhat larger, which they attribute to higher competitiveness gains. Burgert and Roeger (2014) assess the efficiency of both types of fiscal devaluation using the European Commission's QUEST III model. They conclude that the long-run effects are identical in both scenarios; only the short-term efficiency is higher if employees' labor taxes are reduced. To our knowledge, there are no studies simulating fiscal devaluations with DSGE models that simultaneously incorporate a search-and-matching labor market and an intensive and an extensive labor adjustment margin, as we have in this study. The search-and-matching labor market together with two labor adjustment margins explains why there is a difference between cutting personal labor income tax or social security contribution rates primarily through the bargaining process. Our paper shows that, when ignoring the hours margin, a cut in social security contributions dominates a cut in the personal labor income tax rate, in line with the argumentation of Engler et al. (2017). The opposite holds when taking into account the hours margin, which is a result of the stronger increase in available net labor income and a positive wealth effect.

Distributional effects of fiscal devaluation have not gained much attention in the theoretical literature so far. In a micro-simulation study, CPB (2013) and Picos-Sánchez and Thomas (2015) find that fiscal devaluation tends to be regressive. This is confirmed by Burgert and Roeger (2014), especially in a situation in which transfer income recipients are not compensated for the increase in consumption taxes. The CPB (2013) qualifies, however, that if the cuts to social security contributions are targeted to low-income earners, a fiscal devaluation becomes progressive.

3. The Economic Environment

This section first describes the model used in the analysis and then turns to its calibration.

3.1 The Model

Overall, the model is quite a prototypical New Keynesian DSGE model in line with Smets and Wouters (2003, 2007), Christiano, Eichenbaum, and Evans (2005), Christoffel et al. (2009), and Boscá, Doménech, and Ferri (2011) and closely related to Stähler and Thomas (2012). It features a two-country monetary union structure. The integration of a labor market with search characteristics, based on Pissarides (2000), allows the inclusion of involuntary unemployment. We also introduce an intensive margin of labor supply in the model, meaning that labor supply and demand are fully flexible in number of hours. Furthermore, the model also contains a comprehensive public sector. The latter two elements make the model particularly well suited for the purpose of our analysis.

For what follows, we normalize population size of the entire European monetary union to unity, of which $\omega \in (0, 1)$ live in Home (labeled as the periphery), while the remaining $(1 - \omega)$ live in the rest of the EMU (labeled as the core). Throughout the formal model description, quantity variables will be expressed in per capita terms, unless otherwise indicated. Both regions are modeled analogously, while we allow structural parameters to differ. Hence, we restrict ourselves to explaining in detail only the home country. If the explicit description of the foreign country is necessary, we use asterisks to denote decisions made by the corresponding foreign agents as well as the structural parameters.

3.1.1 Households

As in Galí, Lopez-Salido, and Vallés (2007), each country is populated by a share $(1-\mu)$ of Ricardian households who have access to capital markets and, therefore, substitute consumption intertemporally (optimizers). The remaining share $\mu \in [0,1)$ is considered to be liquidity constrained in the sense that they consume all their labor income in each period ("rule-of-thumb," or RoT, household). Each type of household at time $t=0$ maximizes

$$\mathcal{W}_0^i = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \cdot \underbrace{\left(\frac{\left(c_t^i - h \cdot c_{t-1}^i\right)^{1-\sigma_c}}{1-\sigma_c} - \kappa^h \cdot \left(n_t^{i,p} \cdot \frac{{l_t^{i,p}}^{1+\sigma_h}}{1+\sigma_h} + n_t^{i,g} \cdot \frac{{l_t^{i,g}}^{1+\sigma_h}}{1+\sigma_h} \right) \right)}_{= U(c^i, l^{i,p}, l^{i,g})} \right\}, \tag{1}$$

where E_t is the expectations operator conditional on time-t information, c_t^i denotes household consumption of final goods, and the superscripts $i = o, r$ denote optimizing and RoT households, respectively. h denotes the degree of habit formation in consumption.

Inside each household, its members may be employed in the public sector (denoted by $n_t^{i,g}$), employed in the private sector (denoted by $n_t^{i,p}$), or unemployed (denoted by u_t^i), with n expressed in terms of number of hours worked. Households face disutility of providing hours worked, $l_t^{i,p}$ or $l_t^{i,g}$, once employed in one of the two sectors. Disutility increases in the number of hours worked, where κ^h is a scaling parameter and σ_h a shape parameter of the disutility function. As becomes clear below, we will assume full consumption insurance within each household type as in Merz (1995) or Andolfatto (1996).

Households in both countries trade consumption and investment goods as well as international nominal bonds. The consumption and investment baskets, c_t^i and I_t^o, respectively, of a household of type i (only type o for investment) in the home country are given by

$$x_t^i = \left(\frac{x_{At}^i}{\vartheta} \right)^{\vartheta} \left(\frac{x_{Bt}^i}{1-\vartheta} \right)^{1-\vartheta},$$

with $x_t^i = \{c_t^i, I_t^o\}$, where c_{At}^i, I_{At}^o and c_{Bt}^i, I_{Bt}^o represent consumption/investment demand of goods produced in Home (country A) and Foreign (region B), respectively, and $\vartheta = \omega + \psi$ measures the preference for region-A goods, where ψ is a parameter capturing the degree of home bias in private consumption/investment. Note that $\vartheta^* = \omega - \psi^*$. From now onwards, let $p_{Bt} \equiv P_{Bt}/P_{At}$ denote the *terms of trade*, where P_{At} and P_{Bt} are the *producer price indexes* (PPIs) in countries A and B, respectively. Cost minimization by the household then implies $x_{At}^i/x_{Bt}^i = (\vartheta)/(1-\vartheta) \cdot p_{Bt}$. Nominal expenditure in consumption and investment goods equal $P_{At}c_{At}^i + P_{Bt}c_{Bt}^i = P_t c_t^i$ and $P_{At}I_{At}^o + P_{Bt}I_{Bt}^o = P_t I_t^o$, respectively, where $P_t = (P_{At})^{\vartheta}(P_{Bt})^{1-\vartheta}$ is the corresponding *consumer price index* (CPI). Notice that $P_t = P_{At} \cdot p_{Bt}^{1-\vartheta}$. Foreign-country CPI is analogously given by $P_t^* = P_{At}^{\vartheta^*} P_{Bt}^{1-\vartheta^*} = P_{Bt}(1/p_{Bt})^{\vartheta^*}$. Therefore, CPI inflation, $\pi_t \equiv P_t/P_{t-1}$, evolves according to $\pi_t = \pi_{At}(p_{Bt}/p_{Bt-1})^{1-\vartheta}$, where $\pi_{At} \equiv P_{At}/P_{At-1}$ is PPI inflation in country A.

Each household's real labor income (gross of taxes) is given by $w_t^p n_t^{i,p} l_t^{i,p} + w_t^g n_t^{i,g} l_t^{i,g}$, where w_t^p is the hourly real wage paid in the private sector (to be derived later) and w_t^g is the hourly real wage of the government sector. The labor income tax rate is denoted by τ_t^w. Household members who are unemployed receive unemployment benefits κ_t^B. τ_t^c denotes the consumption tax rate and T^i are constant steady-state lump-sum taxes (or, if negative, subsidies) the different household types have to pay (receive) in steady state.

Optimizing households can further invest in physical capital, domestic government bonds, or international assets. Investments in physical capital k_t^o earn a real rental rate r_t^k, while the capital depreciates at rate δ^k. Returns on physical capital net of depreciation allowances are taxed at rate τ_t^k. Nominal government bonds B_t^o pay a gross nominal interest rate R_t. Finally, D_t^o denote holdings of international nominal bonds, which pay the gross nominal interest rate R_t^{ecb}.[4] Π_t^o are nominal per capita profits generated by firms net of vacancy posting costs. We assume that all firms are owned by the

[4]In order to ensure stationarity of international bond holdings, we follow Schmitt-Grohé and Uribe (2003) and assume that there exist portfolio adjustment costs of the form $\psi_d/2\left(d_t - \bar{d}\right)^2$, with $\psi_d > 0$ and $d_t \equiv D_t/P_t$. We assume

optimizing households and that profits are redistributed in a lump-sum manner. Summarizing, the optimizers' period-budget constraint in real terms is

$$\begin{aligned}
&(1+\tau^c)c_t^o + I_t^o + \frac{B_t^o + D_t^o}{P_t} + T^o \\
&\quad = \frac{\Pi_t^o}{P_t} + \left((1-\tau^k)r_t^k + \tau^k\delta^k\right)k_{t-1}^o \\
&\qquad + \frac{R_{t-1}B_{t-1}^o}{P_t} + \frac{R_{t-1}^{ecb}D_{t-1}^o}{P_t} - \frac{\psi_d}{2}\cdot\left(\frac{D_t^o}{P_t} - \frac{\bar{D}^o}{\bar{P}}\right)^2 \\
&\qquad + (1-\tau^w)\left(w_t^p n_t^{o,p} l_t^{o,p} + w_t^g n_t^{o,g} l_t^{o,g}\right) + u_t^o \kappa_t^B, \qquad (2)
\end{aligned}$$

while the one for RoT consumers is given by

$$(1+\tau^c)c_t^r + T^r = (1-\tau^w)\left(w_t^p n_t^{r,p} l_t^{r,p} + w_t^g n_t^{r,g} l_t^{r,g}\right) + u_t^r \kappa_t^B. \qquad (3)$$

Taking into account that RoT households do not own physical capital, the capital law of motion is given by $k_t^o = (1-\delta^k)k_{t-1}^o + \left[1 - S\left(I_t^o/I_{t-1}^o\right)\right] I_t^o$, where $S\left(I_t^o/I_{t-1}^o\right) = \frac{\kappa_I}{2}\left(I_t^o/I_{t-1}^o - 1\right)^2$ represents investment adjustment costs (see Christiano, Eichenbaum, and Evans 2005 for discussion). Maximizing (1) subject to the budget constraint and the capital law of motion yields standard first-order conditions for optimizing households.

3.1.2 Production

The retail and intermediate goods sectors of the economy are similar to Smets and Wouters (2003, 2007) or Christiano, Eichenbaum, and Evans (2005), with the exception that labor services are not hired directly from the households but from a sector of firms that produce homogenous labor services in the manner of Christoffel et al. (2009), de Walque et al. (2009), Boscá, Doménech, and Ferri (2011), or Stähler and Thomas (2012).

Final Goods Producer. There is a measure-ω continuum of firms in the final goods sector, in which firms purchase a variety of

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for simplicity that trading in domestic government and in international bonds is not taxed.

differentiated intermediate goods and bundle these into a final good, which is sold under perfect competition. Assuming that the law of one price holds within the union, the price of the home country's final good is the same in both countries, equal to P_{At}. The problem of the representative retail firm reads $\max_{\{\tilde{y}_t(j):j\in[0,\omega]\}} P_{At}Y_t - \int_0^\omega P_{At}(j)\tilde{y}_t(j)dj$, where $Y_t = \left(\int_0^\omega \left(\frac{1}{\omega}\right)^{1/\epsilon} \tilde{y}_t(j)^{(\epsilon-1)/\epsilon}dj\right)^{\epsilon/(\epsilon-1)}$ with $\epsilon > 1$ is the retailer's production function, $\tilde{y}_t(j)$ is the retailer's demand for each differentiated input $j \in [0,\omega]$, and $P_{At}(j)$ is the nominal price of each input. The standard first-order condition for the problem is given by $\tilde{y}_t(j) = (P_{At}(j)/P_{At})^{-\epsilon} \frac{Y_t}{\omega}$. Combining the latter with the retailer's production function and the zero-profit condition, we obtain that the producer price index in the home country must equal $P_{At} = \left(\int_0^\omega \frac{1}{\omega}P_{At}(j)^{1-\epsilon}dj\right)^{1/(1-\epsilon)}$. Total demand for each intermediate input equals $\omega\tilde{y}_t(j) \equiv y_t(j) = \left(\frac{P_{At}(j)}{P_{At}}\right)^{-\epsilon} Y_t$, as there are ω retail firms.

Intermediate Goods. Each intermediate goods producer $j \in [0,\omega]$ faces the technology

$$y_t(j) = \epsilon^a \cdot \left[\tilde{k}_t(j)\right]^\alpha \cdot \left[\tilde{lab}_t(j)\right]^{(1-\alpha)}, \qquad (4)$$

where $\alpha \in [0,1]$ is the elasticity of output with respect to capital, $\tilde{lab}_t(j)$ denotes the demand for effective labor services, $\tilde{k}_t(j)$ is the demand for effective capital, and ϵ^a is total factor productivity. Following Coenen, Straub, and Trabandt (2013), we assume that effective capital is a constant elasticity of substitution (CES) composite given by

$$\tilde{k}_t(j) = \left(\alpha_k^{\frac{1}{v_k}} \left(k_{t-1}^p(j)\right)^{\frac{v_k-1}{v_k}} + (1-\alpha_k)^{\frac{1}{v_k}} \left(k_{t-1}^g\right)^{\frac{v_k-1}{v_k}}\right)^{\frac{v_k}{v_k-1}},$$

where k_{t-1}^g is the public capital stock available in period t, which is determined by government investment. It is assumed to be productivity enhancing, where $\alpha_k \in (0,1]$ is a share parameter, and the parameter v_k denotes the elasticity of substitution between private capital services and the public capital stock (see also Pappa 2009 and Leeper, Walker, and Yang 2010 for discussion). An analogous aggregator is given for public employment,

$$\tilde{lab}_t(j) = \left(\alpha_g^{\frac{1}{v_g}} \left(N_t^p(j)\, h_t^p(j) \right)^{\frac{v_g - 1}{v_g}} + (1 - \alpha_g)^{\frac{1}{v_g}} \left(N_t^g\, h_t^g \right)^{\frac{v_g - 1}{v_g}} \right)^{\frac{v_g}{v_g - 1}},$$

following Fernández-de-Cordoba, Pérez, and Torres (2012).

Intermediate goods firms acquire private labor and capital services in perfectly competitive factor markets at real (CPI-deflated) prices x_t and r_t^k, respectively. Cost minimization subject to (4) implies the factor demand conditions for capital and labor $r_t^k = mc_t \cdot \alpha \cdot y_t(j)/\tilde{k}_t(j) \cdot \partial\tilde{k}_t(j)/\partial k_{t-1}^p(j)$ and $x_t = mc_t \cdot (1 - \alpha) \cdot y_t(j)/\tilde{lab}_t(j) \cdot \partial\tilde{lab}_t(j)/\partial N_t^p(j)$, where mc_t is the real (CPI-deflated) marginal cost common to all intermediate good producers. The capital-labor ratios are equalized across firms because of constant returns to scale in capital and labor and perfectly competitive (private) input prices.

As is standard in the literature, intermediate goods firms set nominal prices à la Calvo (1983). This implies that a randomly chosen fraction $\theta_P \in [0, 1)$ of firms cannot reoptimize their price in each period. A firm that has the chance to reoptimize its price in period t maximizes $E_t \sum_{z=0}^{\infty} (\beta\theta_P)^z \frac{\lambda_{t+z}^o}{\lambda_t^o} \left[\frac{P_{At}(j)}{P_{t+z}} - mc_{t+z} \right] y_{t+z}(j)$ with respect to the nominal price $P_{At}(j)$, subject to $y_{t+z}(j) = (P_{At}(j)/P_{At+z})^{-\epsilon}\, Y_{t+z}$. λ_t^i represents the marginal consumption utility of households of type i. The first-order condition is standard and implies the standard law of motion for the price level, $1 = \theta_P \left(\frac{1}{\pi_{At}} \right)^{1-\epsilon} + (1 - \theta_P)\tilde{p}_t^{1-\epsilon}$, where $\tilde{p}_t \equiv \tilde{P}_{At}/P_{At}$ is the relative (PPI-deflated) optimal price and $\tilde{P}_{At}$ is the optimal price chosen by all period-t price setters.

3.1.3 The Labor Market

Following Christoffel et al. (2009), de Walque et al. (2009), and Stähler and Thomas (2012), we assume that labor firms hire workers from the household sector in order to produce homogenous labor services, which they sell to intermediate goods producers at the perfectly competitive price x_t. The production function of each labor firm is linear in the number of hours worked by its employee. With

N_t^p being the fraction of the total labor force employed in the private sector and the fact that optimizers and RoTs will work the same amount of hours (which we show below), the total per capita supply of labor services is given by $Lab_t = N_t^P \cdot l_t^p$. Equilibrium in the market for labor services requires that $\omega Lab_t = \int_0^{\omega} lab_t(j)dj$.

Using demand for each intermediate input and the production function (4) plus the fact that the capital-labor ratio is equalized across intermediate goods firms, this yields $Y_t D_t = \epsilon^a \tilde{k}_t^{\alpha} \tilde{Lab}_t^{1-\alpha}$, where $D_t \equiv \int_0^{\omega} \omega^{-1} \left(P_{At}(j)/P_{At}\right)^{-\epsilon} dj$ is a measure of price dispersion. In what follows, we will specify the matching process, flows in the labor market, private-sector vacancy creation, the corresponding wage determination, and labor market participation decisions. Government wages and employment are autonomously chosen by the fiscal authority (see section 3.1.4).

Matching Process and Labor Market Flows. A household member can be in one of three states: (i) employed in the public sector, (ii) employed in the private sector, or (iii) unemployed. Unemployment is the residual state in the sense that a worker whose employment relationship ends flows into unemployment. All unemployed workers search for a job. We assume that searchers are randomly matched to the private or the public sector.

Denoting total sector-specific per capita employment in period t by $N_t^f = (1-\mu)n_t^{o,f} + \mu n_t^{r,f}$, where $f = p, g$ stands for private and government employment, the total economy-wide employment rate is given by $N_t^{tot} = N_t^p + N_t^g$, and the aggregate unemployment rate is given by $U_t = 1 - N_t^{tot}$. Following Blanchard and Galí (2010), we assume that the hiring round takes place at the beginning of each period, and that new hires start producing immediately. We also assume that workers, who are dismissed at the end of period $t-1$, start searching for a new job at the beginning of period t. Therefore, the pool of searching workers at the beginning of period t is given by

$$\tilde{U}_t = U_{t-1} + s^p N_{t-1}^p + s^g N_{t-1}^g,$$

where s^f, with $f = p, g$, represents the constant separation rate in the private (p) and public (g) sector.

The matching process is governed by a standard Cobb-Douglas aggregate matching function for each sector $f = p, g$, $M_t^f = \kappa_e^f \cdot$

$\left(\tilde{U}_t\right)^{\varphi^f} \cdot \left(v_t^f\right)^{(1-\varphi^f)}$, where $\kappa_e^f > 0$ is the sector-specific matching efficiency parameter, $\varphi^f \in (0,1)$ the sector-specific matching elasticity, and M_t^f the number of new matches formed in period t resulting from the total number of searchers and the number of sector-specific vacancies v_t^f. The probability of an unemployed worker finding a job in sector f can thus be stated as $p_t^f = M_t^f/\tilde{U}_t$, while the probability of filling a vacancy is given by $q_t^f = M_t^f/v_t^f$. With the constant separation rate in each sector, the law of motion for sector-specific employment rates is therefore given by

$$N_t^f = \left(1 - s^f\right) \cdot N_{t-1}^f + p_t^f \cdot \tilde{U}_t. \tag{5}$$

Thus, employment in sector f today is given by yesterday's employment that has not been destroyed plus newly created matches in that sector.

Asset Values of Jobs, Wage Bargaining, and Job Creation. As is standard in the literature, we assume that firms and workers bargain about their share of the overall match surplus to determine wages and hours. Following Boscá, Doménech, and Ferri (2009, 2011) and Boscá et al. (2010), we assume that a union, which takes into account (aggregate) utility of optimizing and RoT households, undertakes the bargaining. Furthermore, we assume staggered bargaining of nominal wages similar to Gertler, Sala, and Trigari (2008). This implies that, each period, a randomly chosen fraction θ_w of continuing firms cannot renegotiate wages and hours, while a fraction θ_w^n of newly created firms does not bargain either and is stuck having to pay the previous period's average nominal wage for the average hours worked of the previous period. When letting $J_t\left(\tilde{W}_t^p\right)$ be the value function of employment for firms that are allowed to bargain and $\Omega_t \equiv (1-\mu)H_t^{o,p}\left(\tilde{W}_t^p\right) + \mu H_t^{r,p}\left(\tilde{W}_t^p\right)$ that of the union, where $H_t^{i,p}\left(\tilde{W}_t^p\right)$ is the corresponding household type-i utility, the Nash problem is given by

$$\max_{\tilde{W}_t^p, \tilde{l}_t^p} \; [\Omega_t]^{\xi} \left[J_t\left(\tilde{W}_t^p\right)\right]^{1-\xi}, \tag{6}$$

where $\xi \in [0,1)$ is the union's bargaining power, $\tilde{W}_t^p$ denotes the nominal wage negotiated in period t, and $\tilde{l}_t^p$ denotes the corresponding amount of hours worked. The value function of a firm that renegotiates in that period is given by

$$J_t\left(\tilde{W}_t^p\right) = E_t \sum_{k=0}^{\infty} \left\{ [\beta \cdot (1-s^p) \cdot \theta_w]^k \cdot \frac{\lambda_{t+k}^o}{\lambda_t^o} \cdot \left[x_{t+k} - (1+\tau_{t+k}^{sc}) \cdot \frac{\tilde{W}_t^p}{P_{t+k}} \right] \cdot \tilde{l}_t^p \right\} + (1-\theta_w) \cdot E_t \sum_{k=1}^{\infty} \left\{ [\beta \cdot (1-s^p)]^k \cdot \theta_w^{k-1} \cdot \frac{\lambda_{t+k}^o}{\lambda_t^o} \cdot J_{t+k}\left(\tilde{W}_{t+k}^p\right) \right\},$$

where τ_t^{sc} is the social security contribution rate. The value of the firm is the discounted profit flow in those future states in which it is not allowed to renegotiate plus its continuation value should it have the chance to reoptimize in the next period. For new jobs where firm and worker do not bargain, the nominal wage equals last period's average nominal wage, W_{t-1}^p, the amount of hours is given by l_{t-1}^p, and the value of the job equals

$$J_t\left(W_{t-1}^p\right) = J_t\left(\tilde{W}_t^p\right) - E_t \sum_{k=0}^{\infty} \left\{ [\beta \cdot (1-s^p) \cdot \theta_w]^k \cdot \frac{\lambda_{t+k}^o}{\lambda_t^o} \cdot (1+\tau_{t+k}^{sc}) \cdot \frac{W_{t-1}^p \cdot l_{t-1}^p - \tilde{W}_t^p \cdot \tilde{l}_t^p}{P_{t+k}} \right\}.$$

Analogously, we can derive how workers value a match surplus. Since different household types use different stochastic discount factors,[5]

[5] Actually, RoT consumers are not allowed to use their wealth to smooth consumption over time. But they can take advantage of the fact that a matching today may continue in the future, yielding a labor income that affects consumption tomorrow. Therefore, RoT households use the margin that hours and wage negotiations provide them to improve their lifetime utility by narrowing the gap in utility with respect to optimizers. In this sense, they compare their intertemporal marginal rate of substitution (their "stochastic discount factor") with the one of optimizers; see Boscá, Doménech, and Ferri (2011) for a more detailed discussion.

we must distinguish between the surplus for an optimizing and a rule-of-thumb household. For a worker belonging to a type-i household, the surplus value of a job in a renegotiating firm is given by

$$H_t^{i,p}\left(\tilde{W}_t^p\right) = E_t \sum_{k=0}^{\infty} \left\{ [\beta \cdot (1-s^p) \cdot \theta_w]^k \cdot \frac{\lambda_{t+k}^i}{\lambda_t^i} \cdot \left[(1-\tau_{t+k}^w) \cdot \frac{\tilde{W}_t^p}{P_{t+k}} \cdot \tilde{l}_t^p - \kappa^h \cdot \frac{{\tilde{l}_t^p}^{\,1+\sigma_h}}{(1+\sigma_h)\lambda_{t+k}^i} - \Xi_{t+k}^{i,p} \right] \right\} + (1-\theta_w) \cdot E_t \sum_{k=1}^{\infty} \left\{ [\beta \cdot (1-s^p)]^k \cdot \theta_w^{k-1} \cdot \frac{\lambda_{t+k}^i}{\lambda_t^i} \cdot H_{t+k}^{i,p}(\tilde{W}_{t+k}^p) \right\},$$

for $i = o, r$, where

$$\Xi_t^{i,f} = \kappa_t^B + \beta(1-s^f)E_t \frac{\lambda_{t+1}^i}{\lambda_t^i} \cdot \left\{ p_{t+1}^g H_{t+1}^{i,g} + p_{t+1}^p \left[(1-\theta_w^n) H_{t+1}^{i,p}\left(\tilde{W}_{t+1}^p\right) + \theta_w^n H_{t+1}^{i,p}\left(W_t^p\right) \right] \right\}$$

represents the outside option of a type-i worker employed in sector $f = p, g$ at time t. The latter is the sum of unemployment benefits, κ_t^B, and the expected value of searching for a job in the following period, where p_{t+1}^f is the probability of finding a job in sector $f = p, g$. Conditional on landing on a private-sector job ($f = p$), the surplus value for the worker is contingent on whether the firm is allowed to bargain (in which case the worker receives $\tilde{W}_{t+1}^p$, and works $\tilde{l}_{t+1}^p$ hours) or not (in which case she receives today's average wage, W_t^p, and works l_t^p hours). In new jobs where the wage and hours are not optimally bargained, the surplus value enjoyed by type-i workers is given by

$$H_t^{i,p}\left(W_{t-1}^p\right) = H_t^{i,p}\left(\tilde{W}_t^p\right) + E_t \sum_{k=0}^{\infty} \left\{ [\beta \cdot (1-s^p) \cdot \theta_w]^k \cdot \frac{\lambda_{t+k}^i}{\lambda_t^i} \cdot (1-\tau_{t+k}^w) \cdot \frac{W_{t-1}^p \cdot l_{t-1}^p - \tilde{W}_t^p \cdot \tilde{l}_t^p}{P_{t+k}} \right\}.$$

Note that $H_t^{i,g}$ denotes the surplus value of a government job for a type-i worker. As wages and hours there are autonomously set by the fiscal authority, the asset value function simplifies to

$$H_t^{i,g} = (1-\tau_t^w)w_t^g \cdot l_t^g - \Xi_t^{i,g} - \kappa^h \cdot \frac{l_t^{g\,1+\sigma_h}}{1+\sigma_h} + \beta(1-s^g)E_t\left\{\frac{\lambda_{t+1}^i}{\lambda_t^i} \cdot H_{t+1}^{i,g}\right\},$$

where w_t^g is the real wage paid by the government and l_t^g the amount of hours a worker employed by the government has to work. Given the asset value functions of firms and workers, we are now in a position to solve the wage-bargaining game (6). The resulting sharing rule is given by

$$\Omega_t = \frac{\xi}{1-\xi} \cdot \frac{E_t \sum_{z=0}^{\infty}\left\{\left((1-\mu)\frac{\lambda_{t+z}^o}{\lambda_t^o} + \mu\frac{\lambda_{t+z}^r}{\lambda_t^r}\right)[\beta(1-s^p)\theta_w]^z \frac{(1-\tau_{t+z}^w)}{P_{t+z}}\right\}}{E_t \sum_{z=0}^{\infty}\left\{\frac{\lambda_{t+z}^o}{\lambda_t^o}[\beta(1-s^p)\theta_w]^z \frac{(1+\tau_{t+z}^{sc})}{P_{t+z}}\right\}} \cdot J_t\left(\tilde{W}_t^p\right). \tag{7}$$

Solving equation (7) for $\tilde{W}_t^p$ by using the corresponding asset value functions gives the optimal wage bargained in period t. The average real wage in the private sector, $w_t^p \equiv W_t^p/P_t$, hence evolves according to

$$w_t^p = \frac{(1-s^p)N_{t-1}^p}{N_t^p}\left[(1-\theta_w)\tilde{w}_t^p + \theta_w \cdot \frac{w_{t-1}^p}{\pi_t}\right] + \frac{M_t^P}{N_t^p}\left[(1-\theta_w^n)\tilde{w}_t^p + \theta_w^n \cdot \frac{w_{t-1}^p}{\pi_t}\right], \tag{8}$$

where $\tilde{w}_t^p \equiv \tilde{W}_t^p/P_t$ is the real optimally bargained wage and $w_{t-1}^p/\pi_t = W_{t-1}^p/P_t$ is the real value of yesterday's average nominal wage at today's prices. We have also taken into account the fact that new and continuing jobs pay the optimally bargained wage with probabilities $1-\theta_w^n$ and $1-\theta_w$, respectively.

For the hours determination in the private sector, we get

$$AA_t \cdot \frac{E_t \sum_{z=0}^{\infty} \left\{ \left((1-\mu) \frac{\lambda_{t+z}^o}{\lambda_t^o} + \mu \frac{\lambda_{t+z}^r}{\lambda_t^r} \right) [\beta(1-s^p)\theta_w]^z \frac{(1-\tau_{t+z}^w)}{P_{t+z}} \right\}}{E_t \sum_{z=0}^{\infty} \left\{ \frac{\lambda_{t+z}^o}{\lambda_t^o} [\beta(1-s^p)\theta_w]^z \frac{(1+\tau_{t+z}^{sc})}{P_{t+z}} \right\}}$$

$$= E_t \sum_{z=0}^{\infty} \left\{ \left((1-\mu) \frac{\kappa^h}{\lambda_t^o} + \mu \frac{\kappa^h}{\lambda_t^r} \right) [\beta(1-s^p)\theta_w]^z \right\} \cdot \tilde{l}_t^{p\,\sigma_h}, \tag{9}$$

where $AA_t = E_t \sum_{z=0}^{\infty} \left\{ \frac{\lambda_{t+z}^o}{\lambda_t^o} [\beta(1-s^p)\theta_w]^z x_{t+z} \right\}$. Average hours worked in period t are analogously aggregated as wages; see equation (8).

It remains to determine how jobs are created. As is standard in the literature, we assume that opening a vacancy has a real (CPI-deflated) flow cost of κ_v^p. Following Pissarides (2009), we further assume that free entry into the vacancy posting market drives the expected value of a vacancy to zero. Under our assumption of instantaneous hiring, real vacancy posting costs, κ_v^p, must equal the time-t vacancy filling probability, q_t^p, times the expected value of a filled job in period t net of training costs. The latter condition can be expressed as

$$\frac{\kappa_v^p}{q_t^p} = (1-\theta_w^n) \cdot J_t\left(\tilde{W}_t^p\right) + \theta_w^n \cdot J_t\left(W_{t-1}^p\right), \tag{10}$$

where we take into account that the wage of the newly created job may be optimally bargained with probability $1-\theta_w^n$.

3.1.4 Fiscal Authorities

Defining the (CPI-deflated) per capita value of end-of-period government debt as $b_t \equiv B_t/P_t$, we can state that it evolves according to a standard debt accumulation equation, $b_t = \frac{R_{t-1}}{\pi_t} b_{t-1} + PD_t$, where PD_t denotes real (CPI-deflated) per capita primary deficit. The latter is given by per capita fiscal expenditures minus per capita fiscal revenues,

$$PD_t = \left[\frac{G_t}{p_{Bt}^{1-\omega-\psi}} + \kappa_t^B U_t + \kappa_v^g v_t^g + Sub_t\right]$$
$$- \left[(\tau_t^w + \tau_t^{sc})\left[w_t^p N_t^p l_t^p + w_t^g N_t^g l_t^g\right]\right.$$
$$\left. + \tau_t^c C_t + \tau_t^k (r_t^k - \delta^k) k_{t-1} + (1-\mu) T^o + \mu T^r\right],$$

where G_t denotes per capita government spending in investment, consumption goods, and services expressed in PPI terms (hence the correction for the CPI-to-PPI ratio, $P_t/P_{At} = p_{Bt}^{1-\omega-\psi}$). Letting C_t^g and I_t^g denote real per capita public purchases and public investment, respectively, we have the following nominal relationship: $P_{At} G_t = P_{At}(C_t^g + I_t^g) + (1 + \tau_t^{sc}) P_t w_t^g N_t^g l_t^g$. Dividing by P_{At} and using $P_t/P_{At} = p_{Bt}^{1-\omega-\psi}$, we obtain $G_t = C_t^g + I_t^g + [(1 + \tau_t^{sc}) w_t^g N_t^g l_t^g]\, p_{Bt}^{1-\omega-\psi}$.

We assume that $\kappa_t^B = rrs \cdot (1 - \bar{\tau}^w)\bar{w}^p \bar{l}^p$. Here, rrs is then the unemployment benefit replacement ratio and the bar indicates (initial) steady-state values. Given public investment, the stock of public physical capital evolves as follows: $k_t^g = (1 - \delta^g) k_{t-1}^g + I_t^g$, where we assume that the public capital stock depreciates at rate δ^g. To guarantee stationarity of public debt, for *at least* one fiscal instrument $X \in \{\tau^w, \tau^{sc}, \tau^c, C^g, N^g\}$, the government must follow a fiscal rule of the form

$$X_t = \bar{X} + \rho_X \left(X_{t-1} - \bar{X}\right) + (1 - \rho_X)\, \phi_X \cdot \left(\frac{b_{t-1}}{Y_{t-1}^{tot}} p_{Bt-1}^{1-\omega-\psi} - \omega^b\right) + \epsilon_t^X, \tag{11}$$

in which the coefficient ϕ_X, i.e., fiscal policy's stance on debt deviations from target, is non-zero (positive for revenue instruments, negative for expenditure instruments). ρ_X is a smoothing parameter. Following Galí, Lopez-Salido, and Vallés (2007), T^r is chosen such that, in steady state, optimizing and RoT households consume the same, while T^o closes the government's budget.

3.1.5 International Linkages and Union-Wide Monetary Policy

This section describes the international linkages via trade in goods and foreign assets, market clearing, and the union-wide monetary policy rule.

International Linkages. International linkages between the two countries are given by trade in goods and services as well as in international bonds. The home country's net foreign asset position, expressed in terms of PPI, evolves according to

$$d_t = \frac{R_{t-1}^{ecb} \cdot d_{t-1}}{\pi_{At}} + \frac{1-\omega}{\omega}\left(C_{At}^* + I_{At}^*\right) - p_{Bt}\left(C_{Bt} + I_{Bt}\right), \qquad (12)$$

where $(1-\omega)\left(C_{At}^* + I_{At}^*\right)/\omega$ are real per capita exports and $p_{Bt}\left(C_{Bt} + I_{Bt}\right)$ are real per capita imports. Zero net supply of international bonds implies $\omega d_t + (1-\omega)\, p_t^B d_t^* = 0$. Terms of trade $p_{Bt} = P_{Bt}/P_{At}$ evolve according to $p_{Bt} = (\pi_{Bt}/\pi_{At})\, p_{Bt-1}$.

Equilibrium in Goods Markets and GDP. Market clearing implies that private per capita production in the home and foreign country, Y_t and Y_t^*, respectively, is used for private and public consumption and private and public investment demand as well as private and public vacancy posting costs,

$$\begin{aligned} Y_t &= C_{At} + I_{At} + C_t^g + I_t^g + \frac{1-\omega}{\omega}\left(C_{At}^* + I_{At}^*\right) \\ &\quad + {p_t^B}^{\,1-\omega-\Psi} \kappa_v^p \left(v_t^p + v_t^g\right), \qquad (13) \\ Y_t^* &= C_{Bt}^* + I_{Bt}^* + C_t^{g*} + I_t^{g*} + \frac{\omega}{1-\omega}\left(C_{Bt} + I_{Bt}\right) \\ &\quad + \left(1/p_t^B\right)^{\omega-\Psi^*} \kappa_v^{p*}\left(v_t^{p*} + v_t^{g*}\right), \qquad (14) \end{aligned}$$

where we have assumed that vacancy posting costs in the private and public sector are the same, $\kappa_v^g = \kappa_v^p$. Consistent with national accounting and in line with Stähler and Thomas (2012), each country's GDP is the sum of private-sector production and government production of goods and services. The latter is measured at input costs, that is, by the gross government wage bill. Hence, home and foreign real (PPI-deflated) per capita GDP are given by $Y_t^{tot} = Y_t + (1+\tau_t^{sc}) w_t^g N_t^g l_t^g p_{Bt}^{1-\omega-\psi}$ and $Y_t^{tot,*} = Y_t^* + (1+\tau_t^{sc*}) w_t^{g*} N_t^{g*} l_t^{g*} p_{Bt}^{-(\omega-\psi^*)}$, respectively.

Monetary Authority. We assume that the area-wide monetary authority has its nominal interest rate, R_t^{ecb}, respond to deviations of area-wide inflation from its long-run target, $\bar{\pi}$, and to area-wide GDP growth, according to a simple Taylor rule,

$$\frac{R_t^{ecb}}{\bar{R}^{ecb}} = \left(\frac{R_{t-1}^{ecb}}{\bar{R}^{ecb}}\right)^{\rho_R} \cdot \left\{ \left[\left(\frac{\pi_t}{\bar{\pi}}\right)^{\omega} \left(\frac{\pi_t^*}{\bar{\pi}^*}\right)^{1-\omega} \right]^{\phi_\pi} \left[\left(\frac{Y_t}{\bar{Y}}\right)^{\omega} \left(\frac{Y_t^*}{\bar{Y}*}\right)^{1-\omega} \right]^{\phi_y} \right\}^{(1-\rho_R)},$$

where ρ_R is a smoothing parameter, and ϕ_π and ϕ_y are the monetary policy's stance on inflation and output growth, respectively.

3.1.6 Welfare

In order to assess welfare effects of the reform measures, we compute the lifetime consumption-equivalent gain of each type of household as a result of the change in fiscal policy.[6] We will take into account the welfare difference between the initial and the final steady state as well as the transition thereto. More precisely, we calculate the consumption-equivalent welfare gain, ce^i, such that

$$\sum_{t=0}^{\infty} \left(\beta^i\right)^t U\left((1+ce^i)\bar{c}^i, \bar{l}^p, \bar{l}^g\right) = \sum_{t=0}^{\infty} \left(\beta^i\right)^t U\left(c_t^i, l_t^p, l_t^g\right),$$

where the utility function $U(\cdot)$ is given by equation (1) and the bar indicates initial steady-state values. Hence, ce^i represents the amount of initial steady-state consumption a household of type i is willing to give up in order to live in the alternative regime after the policy change. Economy-wide welfare is computed as $ce^{tot} = (1-\mu)ce^o + \mu ce^r$.

This completes the model description. We now turn to the model calibration.

[6]Among the large literature using consumption equivalents for welfare comparison, see, for example, Obstfeld (1994), Otrok (2001), Krebs (2003), Lucas (2003), Barro (2006), and Cristoffel et al. (2009).

3.2 Calibration

The model is calibrated to quarterly frequency. The home country represents EMU's periphery and the foreign country its core. In what follows, we use the term "country" in the model sense and use the words "home"/"foreign" and "periphery"/"core" interchangeably.[7]

For the general calibration strategy, we broadly rely on Stähler and Thomas (2012). This means that our strategy consists of (i) matching some steady-state variables with their counterparts in the data and (ii) carefully choosing the remaining free parameter values in line with the existing literature. The data we use are largely based on a data set ranging from 1999:Q1 to 2013:Q4 for the euro area containing a rich set of quarterly fiscal variables, described in more detail in Gadatsch, Hauzenberger, and Stähler (2016). The primary sources for the various variables are the European System of Accounts (ESA) for the main aggregates and the European Commission for the fiscal variables. Some labor market variables come from OECD data. Hence, in the initial steady state, we match data averages with the corresponding model variables. Furthermore, given an import share of 15 percent in the periphery (see Balta and Delgado 2009), we normalize periphery per capita GDP, PPI inflation, and the terms of trade to one and set the net foreign asset position to zero. Then, we target home-country import and export shares vis-à-vis the euro area, which is the reason we have to derive the corresponding home bias parameters endogenously. We also set the foreign-country per capita GDP relative to the home-country per-capita GDP according to the relative share of total GDP in EMU. Vacancy filling rates for the euro area are estimated in Christoffel et al. (2009) and assumed to be equal across countries due to the lack of reliable data. The calibration of the labor market parameters is also similar to Moyen, Stähler, and Winkler (2019). Furthermore, we normalize total time available to a household member to one and, hence, assume that, once employed, one-third of total time is devoted to work in the initial steady state, which is a standard

[7]Following Moyen, Stähler, and Winkler (2019), we calibrate the model to seven euro-zone core countries (Austria, Belgium, Germany, Finland, France, Luxembourg, Netherlands) and five periphery countries (Spain, Greece, Ireland, Italy, Portugal).

Table 1. Targeted Steady-State Variables in Baseline Calibration

Targeted Variable	Periphery	Core
Relative Population	0.399	0.601
Real GDP Share	0.347	0.653
Imports-to-GDP Ratio	0.150	NA
Share of Liquidity-Constrained Consumers	0.500	0.460
Public Revenues		
Consumption Tax Rate	0.196	0.183
Capital Tax Rate	0.316	0.214
Labor Income Tax Rate	0.277	0.304
SSC Rate	0.246	0.167
Public Spending		
Gov. Purchases-to-GDP Ratio	0.120	0.110
Gov. Investment-to-GDP Ratio	0.020	0.020
Public-Sector Wage Bill	0.080	0.080
Debt-to-GDP Ratio	0.900	0.750
Labor Market		
Unemployment Rate	0.122	0.084
Public Employees/Total Employment	0.180	0.160
Premium of Public over Private Wages	0.080	0.060
Replacement Rate (Unemployment Benefits)	0.523	0.690
Vacancy Filling Rate (Private)	0.700	0.700
Vacancy Filling Rate (Public)	0.800	0.800

Notes: Tax rates are implicit tax rates. The “NA” for the imports-to-GDP ratio in the rest of the euro area (RoE) is due to the fact that this needs to be derived “endogenously” to match a steady-state net foreign asset position of zero together with a steady-state real exchange rate of one (see table 2).

assumption in the literature. The target values are summarized in table 1.

In choosing the general model parameters, we strongly rely on Christoffel et al. (2009), who estimate a model with a search-and-matching labor market to European data. Note that the simulation results are highly robust to alternative parameter calibration. The discount factor is set to $\beta = 0.992$ to match an annual real rate of 3.2 percent. Risk aversion $\sigma_c = 2$ as well as habits in consumption $h = 0.6$ are set close to the mode estimates in Smets and

Wouters (2003). The share of RoTs, μ, is set to 0.5 in the periphery and 0.46 in the core following Le Blanc et al. (2014). Forni, Monteforte, and Sessa (2009) find similar values for the overall euro area.

We assume that, in the initial steady state, optimizers and RoT households face the same consumption level as in Bilbiie (2008), which determines the values for T^o and T^r. Monetary policy parameters are standard values of a conventional Taylor rule, while the price markup and the Calvo parameters for prices and wages are set in line with estimates from the New Area-Wide Model (see Christoffel, Coenen, and Warne 2008 for a discussion). Capital depreciation is set to a standard value of $\delta^p = \delta^g = 0.025$ and the capital share in production is set to one-third (Cooley and Prescott 1995), while capital adjustment costs are set to a standard value close to 5. For the CES aggregator of private and public capital, we rely on the estimates of Coenen, Straub, and Trabandt (2013), i.e., we set $\alpha_k = 0.9$ and $v_k = 0.84$. Similar values are chosen for the CES aggregator of private and public employment. According to Schmitt-Grohé and Uribe (2003), it is sufficient to choose a rather small value for the risk premium parameter on international bonds in order to generate a stable equilibrium. So we opt for $\Psi_d = \Psi_d^* = 0.01$.

Regarding the labor market, the elasticity of the matching function in the private sector, φ^p, is set to 0.5 in line with Petrongolo and Pissarides (2001), Burda and Weder (2002), and Christoffel et al. (2009). The value in the public sector, φ^g, is set a bit lower, to 0.3, following Afonso and Gomes (2014). The bargaining power of workers is derived endogenously to match the premium of public over private wages. The quarterly separation rate in the private sector is set to 0.04 in line with Christoffel et al. (2009). Again, it is a bit lower in the public sector. For nominal wage rigidities, Colciago et al. (2008), Christoffel et al. (2009), and de Walque et al. (2009) find a rather high degree of stickiness (note that the latter paper is based on U.S. data, however). We opt for a middle value of these studies and set $\theta_w = \theta_w^n = 0.83$.

Given these parameters, it remains to derive the efficiency of the matching function as well as vacancy posting costs endogenously to meet the targeted labor market variables shown in table 1. Values derived endogenously to match the targets are marked by the superscript e in table 2. We perform robustness analysis regarding trade

Table 2. Baseline Parameter Calibration

Parameter	Symbol	Value
Monetary Policy		
Interest Rate Smoothing	ρ_R	0.850
Stance on Inflation	ϕ_π	1.500
Stance on Output Gap	ϕ_y	0.125
Fiscal Policy		
Fiscal Smoothing Parameter	ρ_X	0.900
Stance on Debt	ϕ_X	0.050
Price and Wage Stickiness		
Calvo Parameter (Prices)	θ_P	0.750
Market Power (Markup)	ϵ	4.000
Calvo Parameter (Existing Wages)	θ_w	0.830
Calvo Parameter (New Wages)	θ_w^n	0.830
Preferences		
Discount Rate	β	0.992
Risk Aversion	σ_c	2.000
Habits in Consumption	h	0.600
Trade in International Bonds		
Risk Premium Parameter	$\psi_d = \psi_d^*$	0.010
Production		
Private-Sector Capital Depreciation	δ^k	0.025
Public-Sector Capital Depreciation	δ^g	0.025
Private-Sector Capital Share in Prod.	α	0.330
Public-Sector Capital/Employment Influence in Private Production	α_k, α_g	0.900
Substitutability Public/Private Capital/Employment	υ_k, υ_g	0.840
Adjustment Cost Parameter	κ_I	4.940
Labor Market		
Matching Elasticity (Private Sector)	φ^p	0.500
Matching Elasticity (Public Sector)	φ^g	0.300
Separation Rate (Public Sector)	s^g	0.020
Separation Rate (Private Sector)	s^p	0.040
Labor Market Matching Efficiency[e]	κ_e^p	0.360
Vacancy Posting Costs[e]	κ_v^p	2.040
Bargaining Power of Workers[e]	ξ	0.200

openness, labor market efficiency, and country size. As can be seen in the results section, our results are robust to parameter changes.

4. Simulation Design

In order to assess the macroeconomic effects of reducing the tax wedge, we calibrate a reduction in the labor income tax and/or social security contribution rates that yields an increase in the governments' primary deficit-to-GDP ratio by 1 percentage point ex ante, that is, holding constant everything other than changes in the stated instruments. A higher (lower) reduction in the tax/contribution rates would, naturally, imply stronger (weaker) long-run effects. In order to compensate for the revenue losses, we then calculate an increase in other revenue components (consumption taxes) or a decrease in the expenditure components (public purchases or employment) such that the budget will be balanced ex post in the new steady state which takes into account the "second-round effects" resulting from changes in endogenous variables.[8]

For all simulations, we assume that the economy is initially in steady state. Each fiscal measure is implemented by changing the corresponding long-run target (parameter) such that the measure is permanent. We then derive the final steady state that arises after the policy change and calculate the transition from the initial to the final steady state under perfect foresight. In this calculation, we assume that no other shocks hit the economy during the transition path, which allows us to attribute all the effects to the policy measure.

[8]Technically, this is done by allowing only the steady-state value of the financing fiscal instrument that we consider to adjust according to equation (11). Assuming the targeted debt-to-GDP ratio to remain unchanged, this calculates the final steady-state value of the financing instrument which balances the government's budget and takes into account the "second-round effects." If we assume that the public-sector budget constraint is balanced ex ante (i.e., ignore the second-round effects and assume lump-sum taxes to stabilize debt in the long run), the necessary increase in the consumption tax rate must be larger and the positive effect turn out to be smaller. While the results are, overall, equivalent, this hurts RoT consumers along the transition after a cut in social security contributions because the resulting wage increase is not sufficient to immediately compensate for the policy-induced rise in consumption costs. Results of such an analysis can be found in an earlier version of the paper (see Attinasi et al. 2016).

5. Simulation Results

In this section, we present long-run effects and transition dynamics for each reform measure described above. Results are reported in percentage deviations of key macroeconomic variables from their initial steady-state values (percentage-point deviations for rates and ratios). To get a better understanding of the transmission mechanisms, we will show impulse response functions (IRFs) for selected simulations.

5.1 Reducing the Tax Wedge and Different Financing Schemes

In a first step, we assess the effects of a reduction in the labor tax wedge implemented as a reduction in either the personal income tax (PIT) paid by employees or the social security contributions (SSC) paid by the employers, assuming that it is financed by an increase in the consumption tax rate. In a second step we look at the implications of using expenditure instruments to finance the corresponding revenue loss.

5.1.1 Fiscal Devaluation: Comparing Workers' and Firms' Tax Rate Reductions

Table 3 displays the long-run changes of selected key macroeconomic variables after a fiscal devaluation episode in the periphery when (i) reducing the workers' personal labor income tax rate and when (ii) reducing the firms' social security contribution rate only. In these simulations, it is assumed that the reduction in the labor tax wedge is always financed by an appropriate increase in the consumption tax rate. The transition dynamics of selected key macroeconomic variables are shown in figure 1. Furthermore, table 3 shows the results of simulations with a lower home bias, a lower labor market efficiency, or a smaller country size.[9]

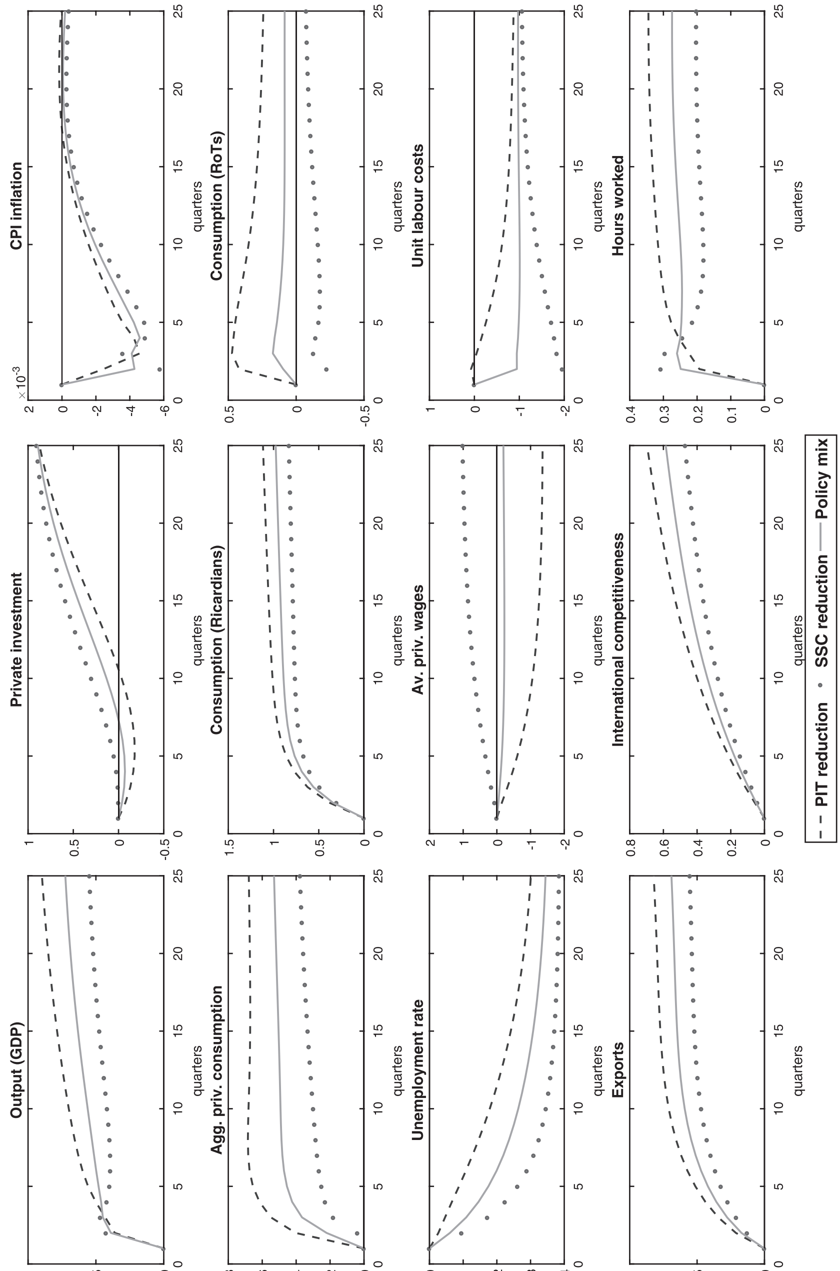
[9] For the robustness analyses, we assume that the home bias is decreased such that, relative to the baseline scenario, the import share is doubled (HB $\Psi \downarrow$), vacancy posting costs are increased by 25 percent (LME $\xi \downarrow$), and the size of the home country is only 10 percent (CS $\omega \downarrow$).

Table 3. Permanent Effects of Fiscal Devaluation in the Periphery

Long-Run Changes in	Baseline		HB ↓		LME ↓		CS ↓	
	ΔPIT	**ΔSSC**	**ΔPIT**	**ΔSSC**	**ΔPIT**	**ΔSSC**	**ΔPIT**	**ΔSSC**
GDP	1.04	0.83	1.02	0.81	1.13	0.92	1.05	0.83
Private Consumption	0.79	0.49	0.61	0.37	0.87	0.52	0.85	0.53
… of Optimizers	1.31	0.94	1.02	0.75	1.50	1.08	1.41	1.01
… of RoTs	0.27	0.03	0.20	−0.01	0.24	−0.05	0.30	0.05
Private Investment	0.82	0.69	0.64	0.57	0.96	0.82	0.89	0.74
Unemployment Rate	−0.33	−0.39	−0.30	−0.37	−0.35	−0.42	−0.35	−0.40
Per Capita Hours (Private)	0.93	0.54	1.02	0.60	0.99	0.60	0.90	0.52
Total Hours (Private Sector)	1.40	1.09	1.44	1.12	1.48	1.19	1.39	1.08
Average Gross Wages	−1.22	1.16	−1.40	1.04	−1.37	1.03	−1.15	1.21
Average Net Wage Income	4.05	1.71	3.95	1.65	4.18	1.63	4.09	1.74
Unit Labor Costs	−0.96	−1.07	−1.07	−1.15	−1.12	−1.33	−0.92	−1.04
Internat. Competitiveness	1.08	0.71	1.05	0.70	1.13	0.73	1.10	0.73
PIT Rate	−2.98	0.00	−2.98	−0.00	−2.98	0.00	−2.98	−0.00
SSC Rate	0.00	−2.98	0.00	−2.98	0.00	−2.98	0.00	−2.98
Consumption Tax Rate	1.45	0.62	1.49	0.65	1.51	0.68	1.43	0.61
RoE GDP	0.02	0.01	0.03	0.02	0.02	0.01	0.00	0.00

Notes: The table shows deviations of final relative to initial steady-state values in percent (percentage points for rates and ratios). Changes in hours are in percent. International competitiveness is given by foreign prices divided by domestic ones. Columns 1 and 2 show the results for the baseline calibration for PIT and SSC, respectively, while the remaining columns show the results for the robustness analysis of relevant model parameters, which are lower HB = home bias, lower LME = labor market efficiency, and lower CS = country size.

Figure 1. Transition Dynamics (IRFs) for Fiscal Devaluation in the Periphery



The following results stand out. On the one hand, a reduction in labor taxation, regardless of whether on the employees' or employers' side, permanently reduces unit labor costs and induces firms to reduce prices via the marginal costs channel. Lower prices are beneficial to international competitiveness and foster exports. Lower unit labor costs increase labor demand through the creation of additional jobs and/or an increase in the amount of hours worked in the medium run. In the case of the former, unemployment falls. Taken together, aggregate domestic demand for private goods rises. This, plus higher foreign/export demand, increases output, which also fosters the incentive for capital investment. On the other hand, the increase in the consumption tax rate dampens domestic private consumption ceteris paribus, as it makes consumption spending more expensive. The total effect on private consumption turns out to be positive in our simulations, while the size of the impact depends on whether the personal income tax or the social security contribution rate is reduced, because the former increases net labor income by more than the latter.

Focusing on the first-round effects, the impact on consumption differs significantly between the two labor tax instruments. When social security contributions are decreased, the increase in aggregate net wage income is not sufficient to compensate for the increase in consumption costs, and the consumption of rule-of-thumb (RoT) households falls on impact. However, in this case, capital-holding households benefit from higher expected future wealth (due to a permanent rise in output). Under the permanent-income hypothesis, capital-holding households immediately consume more already on impact. When the personal income tax rate is reduced, the increase in net labor income compensates for the higher costs of consumption. As a result, the consumption of RoT households, who spend their entire income each period, already increases on impact (see figure 1). Hence, total private consumption increases more when the personal income tax is reduced.

In the medium to long run, the total impact on consumption and GDP is the result of the mechanisms in the search-and-matching labor market that is incorporated in our model. In what follows, we will restrict ourselves to an intuitive explanation of the different transmission mechanisms after reducing either labor income tax or social security contribution rates. In section 5.1.2 we will shed more light on which assumptions in our model are responsible for these results.

For any given gross wage, a decrease in the labor income tax rate immediately augments net wage income. Workers are then willing to accept lower gross wages in the bargaining process as, everything else equal, they target a certain total net wage income. Thus, private wage claims eventually fall (see the dashed line in figure 1 for the transition and see table 3 for the long run), reducing unit labor costs and increasing the incentive for firms to create jobs and to augment employment. Even though gross wages fall, households' net wage income increases because the gross wage reduction is overcompensated by the reduction in the labor income tax rate. Therefore the consumption of RoT households, who spend their entire per-period income, increases.

A decrease in the social security contribution rate (see the dotted line in figure 1 for the transition and see table 3 for the long run) directly affects the unit labor costs of firms without having to take the detour via the wage-bargaining channel. Again, the fall in unit labor costs increases the incentive for firms to create jobs and augments employment as well as firms' profits. However, it does not have a direct impact on consumers' net income. Since higher employment implies higher chances for unemployed workers to find a job, their fallback position in the wage-bargaining game increases. This augments their reservation wage and, hence, wage claims. Still, unit labor costs fall because wages increase by less than social security contributions fall (unit labor costs are defined as the aggregated gross wage payments including social security payments divided by private-sector output). Relative to a decrease in the personal labor income tax rate, the fall in unit labor costs is stronger on impact and for the first four years.[10] The positive GDP effect is relatively weaker because private consumption demand increases by less.

The different effects of a personal income tax reduction compared with a reduction of social security contributions are crucially driven by the presence of an intensive margin with fully flexible

[10]In the long run, this is reversed because a reduction in the personal labor income tax rate also increases the supply of hours worked (see next paragraph), which gives workers more leeway to accept a lower gross wage while keeping a high enough total net income.

labor hours in our model. This intensive margin allows firms to adjust employment as an input to production differently in the two scenarios. When the personal income tax rate is reduced, the increase in net labor income of workers incites workers to supply more hours. Moreover, it is less costly for firms to produce additional output by increasing working time of those already employed relative to employing more workers, as the latter involves hiring/search costs. On the contrary, when the firms' tax burden is decreased, the increase in net labor income received by workers is lower, and so is the (voluntary) supply of additional working hours. As a result, firms prefer to hire more workers instead of increasing working time. Hence, the total amount of hours worked increases more in case of a personal income tax rate reduction, while unemployment falls more in the case of a reduction in social security contributions (see table 3). In section 5.1.2 we show the importance of incorporating an intensive hours margin in our model.

Interestingly, to achieve budget neutrality, a personal income tax reduction requires a stronger increase in consumption taxes than reducing social security contributions. This is due to the different transmission of the two different measures to wages. As already mentioned, workers accept lower gross wages when reducing the personal labor income tax rate because their net labor income is immediately increased due to the tax rate reduction. On the contrary, gross wage claims are increased after a cut in the social security contribution rate as a result of the bargaining process. Gross wages income is the basis for both personal labor income taxes and social security contributions. Hence, lower wages in the former scenario result in a relatively higher loss of public revenues than a wage increase in the latter scenario, which has to be financed by relatively higher consumption taxation. Summarizing, the model simulations show that from an efficiency perspective—in terms of higher output—lowering labor taxes on the employees' side yields larger gains. This also holds from a redistribution perspective, as it does not harm liquidity-constrained households' consumption. These findings are also in line with Coenen et al. (2012). However, from the perspective of reducing the unemployment rate, a decrease in social security contributions seems more appropriate because, in that case, firms and workers are less inclined to use the intensive margin to increase production. Most of the tax wedge reductions in the past have been a combination of reducing workers' and firms' contribution rates at the same time. The results of such a simulation are presented by the solid line in figure 1. As we see, the impact of this policy mix is a weighted average of both previous simulations. In all cases, spillovers to the core are positive but small, and our results are quite robust to alternative specifications of the periphery's size, trade openess, or labor market efficiency (see table 3).

Even though output and consumption increase more in the case of a personal income tax rate reduction, the effects on welfare are not straightforward because, in this case, the disutility of providing more working hours increases. This is discussed in more detail in section 6.

5.1.2 The Role of Search Frictions and Endogenous Hours Worked

Literature has shown that, in a frictionless world with flexible wages, labor income tax and social security rate reductions are equivalent (see, for example, Lipinska and von Thadden 2012; Engler et al. 2017). This is because, in both cases, wages and labor costs adjust to the same new equilibrium level irrespective of whether the personal income tax or social security tax rates are decreased. In the presence of staggered wage setting, the adjustment of labor costs when lowering the personal labor income tax rate is postponed relative to a reduction in the firms' social security contribution rate, as the latter directly affects labor input costs. Therefore, Engler et al. (2017) find that cutting social security contributions is more beneficial in the short and medium term.[11] In a model with a search-and-matching labor market, the equivalence of personal labor income tax or social security contribution rate reduction in the long run must no longer apply. In these models with a frictional labor market with

[11] Also note that, in this paper, we perform a fully non-linear simulation under perfect foresight that takes into account the fact that the initial and the final steady states are different. This introduces a positive net wealth effect in the long run. Instead, Engler et al. (2017) assume very persistent tax shocks and perform a linear simulation of their model, hence ignoring this wealth effect. Comparing the results shows that, in addition to the different labor market structures, it is also important to actually take into account the final steady state when discussing long-term structural changes.

the standard Nash bargaining over the match surplus—which is also a key feature of our model—personal income taxes and social security contributions affect the bargaining position of workers and firms differently. The following argumentation of the underlying reasons for these results is more formally derived in the appendix.

In general, a reduction in the personal labor income tax rate on the workers' side decreases the workers' outside option in relative terms (i.e., the utility difference between working and not working increases as a result of the policy-induced rise in net wage income). Therefore, workers accept lower wages in the bargaining process, which eventually reduces labor costs for firms. A reduction in the social security contribution rate for firms leaves the workers' outside option nearly unchanged ceteris paribus. However, as the latter increases firms' profits, and the bargaining process determines the share of these profits accruing to the worker, wage claims rise after a reduction in the social security contribution rate. The net effect on labor costs depends on whether the gross wage reduction (after a cut in the personal labor income tax rate) or the direct tax cut (after a reduction in the social security contribution rate) yields stronger effects.

In our model, the outside option of workers depends on unemployment benefits and the expected wage income when finding a job in the public sector. As unemployment benefits relate to net wages, and taxes also have to be paid by public-sector workers, the outside option is affected little after a cut in the personal labor income tax rate. Hence, when ignoring the endogenous evolution of hours worked, we find that cutting social security contributions paid by firms is more beneficial in terms of output, consumption, and employment gains. Table 4 summarizes the results of a simulation in which we keep hours worked fixed at their initial steady-state values. Thus, in this simulation, our model confirms the finding that a cut in the firms' labor tax burden is more beneficial. As table 3 shows, this no longer holds when taking into account the intensive adjustment margin.

The possibility of adjusting the number of hours per worker in the model, next to the decision whether to hire a new worker or not, changes the impact of a reduction in the labor income tax vis-à-vis a reduction in the social security contribution significantly (again, the formal analysis can be retraced in the appendix). As we have

Table 4. Permanent Effects of Fiscal Devaluation in the Periphery with Exogenously Fixed Hours Worked

Long-Run Changes in	ΔPIT	ΔSSC
GDP	0.31	0.40
Private Consumption	0.05	0.06
Private Investment	0.30	0.39
Unemployment Rate	−0.28	−0.37
Per Capita Hours (Private)	0.00	0.00
Average Gross Wages	−0.77	1.43
Average Net Wage Income	3.56	1.43
Unit Labor Costs	−0.72	−0.93
International Competitiveness	0.12	0.15
PIT Rate	−2.98	−0.00
SSC Rate	0.00	−2.98
Consumption Tax Rate	1.81	0.83
RoE GDP	0.01	0.02

Notes: The table shows deviations of final relative to initial steady-state values in percent (percentage points for rates and ratios) after fiscal devaluation for baseline calibration. International competitiveness is given by foreign prices divided by domestic ones.

seen in the model description, workers equate marginal disutility of providing hours with the resulting benefits. A cut in the personal labor income tax rate increases wages/benefits and, thus, the incentives of providing additional hours rise. Furthermore, for firms, it is less costly to extend hours relative to employing an additional worker when extending production (and, thus, labor input), as they can save on search costs. Therefore, augmenting labor input via the hours margin becomes more attractive. This further fosters wage income, consumption, and output. The incentive for workers to provide additional hours increases more after a cut of the personal labor income tax rate than after a cut in the social security contribution rate. The reason is that benefits of providing hours (resulting from the net wage increase) are stronger when the tax burden of workers is decreased, as it has a more direct impact on net wages received by workers (when social security contributions are cut, the wage increase results indirectly through bargaining). Our model simulations show that this effect dominates the job-creation effect such that, when taking into account endogenously determined hours, a cut in the personal labor income tax rate is more beneficial (see table 3).

5.1.3 Alternative Fiscal Instruments to Finance Labor Tax Reductions

We now look at the macroeconomic effects of a decrease in the labor tax wedge when this is financed by alternatively reducing government purchases, C^g, and public employment, N^g. The reduction in the workers' personal income tax rate is taken as the benchmark.

Figure 2 compares a reduction in public purchases and a reduction in public employment to finance the decrease in the tax wedge to a fiscal devaluation in the periphery. Financing a tax wedge reduction via lower government purchases has negative short-run effects on GDP, as it reduces aggregate demand. No adverse effects for consumption of liquidity-constrained households materialize, as they benefit from lower labor taxes. In particular, private consumption of both capital-holding and RoT households increases, as lower labor taxes translate immediately into a higher net wage income while the dampening effect of higher consumption taxes is absent. The improvement in international competitiveness, via lower unit labor costs, increases private consumption and exports. But this is not sufficient to compensate for the loss in public consumption, and GDP declines initially. The negative effect of reduced public consumption is reversed when the labor market improvements resulting from lower labor taxes and the positive wealth effect for optimizers start to materialize. In the medium term, private employment and wages start to increase on the back of higher domestic consumption and exports. This is a result of eventually higher reemployment chances and, therefore, increased fallback utility of (unemployed) workers. Nonetheless, higher private consumption in the long run only slightly compensates for the 1 percentage point loss in public consumption which, in contrast to private consumption, is assumed to entail a full home bias (see table 5). Hence, the private demand-driven GDP increase is dampened, which also implies lower

Figure 2. Transition Dynamics (IRFs) for Alternative Financing Schemes in the Periphery

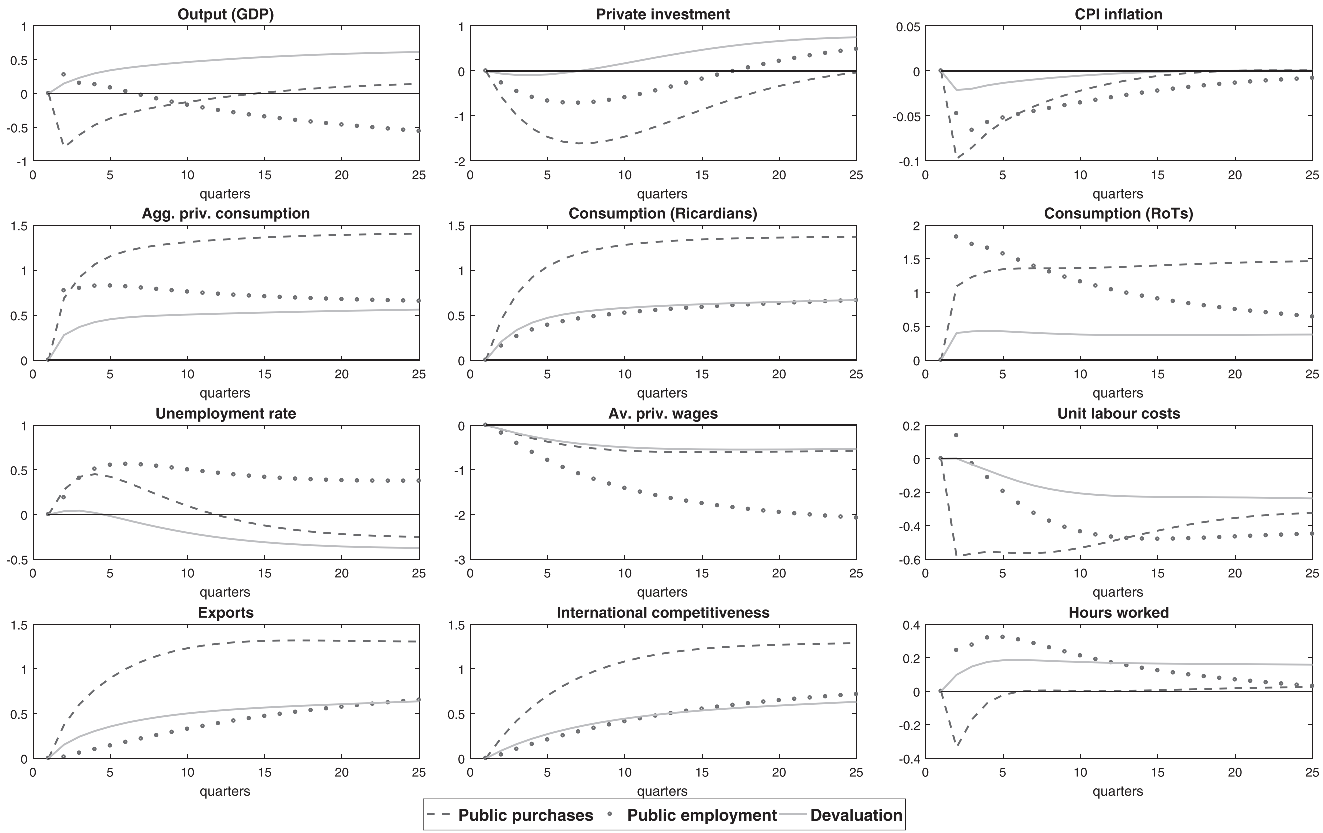


Table 5. Permanent Effects of Financing PIT Reduction with Public Purchases and Employment in Periphery

Long-Run Changes in	Baseline		HB ↓		LME ↓		CS ↓	
	ΔC^g	ΔN^g	ΔC^g	ΔN^g	ΔC^g	ΔN^g	ΔC^g	ΔN^g
GDP	0.57	0.11	0.50	0.02	0.64	0.27	0.59	0.14
Private-Sector Output	0.61	1.61	0.54	1.58	0.69	1.81	0.64	1.62
Private Consumption	1.49	1.29	1.24	1.03	1.63	1.42	1.57	1.38
. . . of Optimizers	1.63	1.98	1.20	1.56	1.87	2.33	1.78	2.14
. . . of RoTs	1.35	0.59	1.29	0.50	1.39	0.51	1.37	0.63
Private Investment	0.16	1.13	−0.16	0.84	0.31	1.39	0.28	1.23
Unemployment Rate	−0.22	0.47	−0.16	0.57	−0.24	0.38	−0.24	0.44
Private Employment	0.22	2.24	0.16	2.27	0.24	2.38	0.24	2.23
Per Capita Hours	0.59	−0.15	0.71	−0.06	0.62	−0.14	0.55	−0.18
Total Hours (Private Sector)	0.89	2.97	0.93	3.10	0.95	3.17	0.88	2.92
Average Gross Wages	−1.26	−2.50	−1.55	−2.85	−1.35	−2.88	−1.16	−2.38
Average Net Wage Income	3.65	1.71	3.48	1.45	3.82	1.57	3.71	1.80
Unit Labor Costs	−0.99	−1.15	−1.17	−1.34	−1.10	−1.51	−0.93	−1.08
Internat. Competitiveness	1.65	1.70	1.64	1.68	1.72	1.79	1.67	1.72
PIT Rate	−2.98	−2.98	−2.98	−2.98	−2.98	−2.98	−2.98	−2.98
Public Purchases	−6.72	0.00	−7.02	0.00	−6.71	0.00	−6.61	0.00
Public Employment Rate	−0.00	−2.72	−0.00	−2.84	0.00	−2.76	−0.00	−2.67
Core GDP	0.03	0.03	0.05	0.05	0.03	0.03	0.00	0.00

Notes: The table shows deviations of final relative to initial steady-state values in percent (percentage points for rates and ratios). Changes in hours are in percent. International competitiveness is given by foreign prices divided by domestic ones. Columns 1 and 2 show the results for the baseline calibration of a PIT reduction financed by a decrease in government consumption and government employment, respectively. The remaining columns show the results for the robustness analysis of relevant model parameters, which are lower HB = home bias, lower LME = labor market efficiency, and lower CS = country size.

effects on overall employment (level and hours worked) in the long run. The GDP-dampening effect of lower public purchases is smaller in countries with a relatively high home bias in private consumption and investment and a relatively low labor market efficiency. Hence, those countries gain more when financing the reduction in the labor tax wedge by lower public purchases.

Two opposing effects are at work, when the labor tax wedge is financed by a decrease in public employment (dotted line in figure 2).

On the one hand, there is a "wage channel" which improves aggregate private output. A decrease in public employment diminishes the probability of finding a job in the public sector, thereby decreasing the workers' fallback utility. Hence, workers will accept lower wages in the private sector beyond what the reduction in the personal income tax rate would entail. This eventually improves unit labor costs and fosters private employment and international competitiveness. The unemployment rate increases even though private employment increases significantly. This is due to the fact that the private sector does not fully absorb the employment reductions in the public sector.

On the other hand, there is a "productivity channel" which lowers aggregate output. As public employees are assumed to positively contribute to private-sector productivity, a reduction in public employment dampens private-sector production capacities. Which of the two effects dominates depends on the relative size of these effects. The wage channel is larger the more workers rely on their fallback utility in the bargaining game. This is the case if the workers' bargaining power vis-à-vis the firms is low. In such a situation, wages fall relatively more after a cut in public employment such that private-sector wage reductions can dominate productivity losses and further improve private-sector output. However, it may have negative distributional consequences in terms of optimizers' and RoTs' consumption behavior (the latter increasing much less) because it shifts income from wages to firms' profits, which belong to optimizers only. In our simulations, the wage channel always dominates and private-sector outcome increases. Hence, we observe an increase in GDP. This is despite the fact that we have defined GDP as the sum of private-sector output and public production evaluated at input costs in line with national accounting (see Stähler and Thomas 2012 for a more detailed discussion).[12]

6. A Welfare Perspective

We are now interested in how to evaluate these reforms in terms of the well-being of the reforming country's population. The advantage of having a theoretical model like ours is that we are able to calculate (household-type-specific) welfare to address this issue. In doing so, we compute the lifetime-consumption-equivalent gain of each type of household in line with Lucas (2003) as a result of the change in fiscal policy. Results are presented in table 6. We first show the welfare difference between the initial and the final steady state and, in a second step, the welfare effects including the transition thereto. The numbers presented in the tables can be interpreted as how much of initial steady-state consumption (in percent) a household would be willing to give up in order to be indifferent between living in the original or in the alternative regime (after the reform). Positive values therefore imply a welfare gain, while negative values signal a welfare loss.

Table 6 shows that a fiscal devaluation via a reduction in the firms' social security contributions always hurts liquidity-constrained consumers. In this case, the gain in net labor income cannot overcompensate for the policy-induced increase in consumption costs. Welfare decreases because, despite lower per capita input of working hours, the loss in consumption utility is too strong to be compensated for. Only because the gains in firms' profits are strong enough to boost optimizers' consumption sufficiently is this measure not detrimental to welfare. Yet, it is still not a Pareto improvement. Once taking into account the transition path, welfare of liquidity-constrained households decreases even more because of the strong

[12]Note furthermore that, in addition to what has just been explained, how the wage and the productivity channels are related is strongly affected by the "efficiency" of the public sector. If the public sector is deemed to be inefficient, this clearly goes in favor of the wage channel. If one believes that the public sector is less efficient in one country than in others, this will strengthen the wage channel in that economy further and, therefore, make this measure relatively more attractive. If private output can be boosted sufficiently, this may overturn the negative GDP effect, which is the case in our simulation.

Table 6. Welfare Gains/Losses in Periphery

Simulation	Baseline			HB ↓			LME ↓			CS ↓		
	ce^o	ce^r	ce^{tot}	ce^o	ce^r	ce^{tot}	ce^o	ce^r	ce^{tot}	ce^o	ce^r	ce^{tot}
In Steady State												
Devaluation (PIT)	1.21	0.18	0.70	0.93	0.11	0.52	1.40	0.14	0.77	1.32	0.21	0.76
Devaluation (SSC)	0.88	−0.03	0.42	0.69	−0.08	0.30	1.01	−0.12	0.45	0.95	−0.01	0.47
PIT and Public Purchases Cuts	1.57	1.29	1.43	1.13	1.22	1.18	1.81	1.33	1.57	1.72	1.31	1.52
PIT and Public Employment Cuts	2.02	0.63	1.32	1.59	0.53	1.06	2.36	0.55	1.45	2.17	0.66	1.42
Including Transition												
Devaluation (PIT)	1.09	0.19	0.64	0.84	0.12	0.48	1.25	0.15	0.70	1.17	0.19	0.68
Devaluation (SSC)	0.81	−0.07	0.37	0.64	−0.11	0.26	0.91	−0.15	0.38	0.86	−0.07	0.39
PIT and Public Purchases Cuts	1.52	1.28	1.40	1.14	1.22	1.18	1.73	1.31	1.52	1.66	1.29	1.47
PIT and Public Employment Cuts	1.13	0.96	1.05	0.71	0.89	0.80	1.39	0.91	1.15	1.27	0.98	1.12

Notes: The table presents steady-state welfare gains/losses after the reform measures simulated in section 5 in terms of how much of initial steady-state consumption (in percent) a household of type $i = o, r$ would be willing to give up in order to be indifferent between living in the original or in the alternative regime (first section, "in steady state"). We then calculate the welfare gains/losses including the transition paths (first section, "including transition"). Total economy-wide welfare gains/losses are defined as $ce^{tot} = (1-\mu)ce^o + \mu^r$, where μ is the share of rule-of-thumb consumers.

initial drop in their consumption on impact. On the contrary, fiscal devaluation by means of a reduction in the workers' personal income tax rate affects welfare positively because, in this case, the negative effect on RoTs' consumption vanishes. Again, when taking into account the transition path, welfare gains are somewhat lower because it takes time to reach the final steady-state values.

Moreover, table 6 also reveals that, in terms of welfare, financing a reduction in the labor tax wedge via a cut in public purchases is superior to a fiscal devaluation, even though the former measure generates significantly lower output gains (see section 5.1.3). This is because reductions in public purchases do not increase consumption costs, while having similar labor market effects. Therefore, the increase in consumption of optimizing and liquidity-constrained consumers is much stronger, translating into higher welfare gains. This also holds when taking into account the transition to the new steady state, again with somewhat lower gains because it takes time to reach the new steady state. A similar argument holds for using a public employment reduction as the financing instrument because, as we have seen in the previous section, this boosts private-sector employment and the increase in aggregate net wage income significantly.

As we have seen above, there are no negative spillovers to the rest of the euro area in terms of output and/or consumption losses. Still, it may be interesting to assess how welfare in the rest of the euro area is affected if one country/region in the euro area reduces its labor tax wedge in a budget-neutral way. Table 7 summarizes the welfare effects in the rest of the euro area—the core in our model. Given the spillovers generated by the tax wedge reduction in the periphery, there are two opposing welfare effects for the rest of the euro area. On the one hand, higher private demand for foreign goods in the periphery increases labor and capital income in the core, ultimately implying higher consumption and, thus, higher welfare there, too. On the other hand, higher output is also produced by augmented labor input, decreasing welfare correspondingly. If the increase in income and, thus, consumption is sufficiently strong to overcompensate for the increase in the disutility of work, households in the core gain. This is the case if private consumption and investment demand in the periphery increases relatively more, which holds more for measures strongly fostering private demand (such as financing the labor tax wedge reduction by public employment

Table 7. Welfare Gains/Losses in Core

Simulation	Baseline			HB ↓			LME ↓			CS ↓		
	ce^o	ce^r	ce^{tot}	ce^o	ce^r	ce^{tot}	ce^o	ce^r	ce^{tot}	ce^o	ce^r	ce^{tot}
In Steady State												
Devaluation (PIT)	−0.04	−0.03	−0.03	−0.03	−0.04	−0.03	0.06	−0.00	0.03	−0.03	−0.05	−0.04
Devaluation (SSC)	0.02	0.01	0.02	0.02	0.01	0.01	0.05	0.02	0.03	−0.01	−0.01	−0.01
PIT and Public Purchases Cuts	0.00	−0.01	−0.01	0.01	−0.02	−0.00	0.18	0.03	0.11	0.05	−0.01	0.02
PIT and Public Employment Cuts	0.07	0.04	0.05	0.09	0.04	0.07	0.14	0.05	0.10	0.13	0.06	0.10
Including Transition												
Devaluation (PIT)	−0.04	−0.03	−0.04	−0.03	−0.03	−0.03	0.06	−0.00	0.03	−0.03	−0.04	−0.04
Devaluation (SSC)	0.02	0.01	0.02	0.02	0.01	0.01	0.05	0.02	0.04	−0.01	−0.01	−0.01
PIT and Public Purchases Cuts	−0.00	−0.01	−0.01	0.02	−0.01	0.00	0.18	0.05	0.12	0.06	0.01	0.04
PIT and Public Employment Cuts	0.05	0.02	0.04	0.06	0.02	0.04	0.10	0.02	0.07	0.07	0.01	0.04

Notes: The table presents steady-state welfare gains/losses after the reform measures simulated in section 5 in terms of how much of initial steady-state consumption (in percent) a household of type $i = o, r$ would be willing to give up in order to be indifferent between living in the original or in the alternative regime (first section, "in steady state"). We then calculate the welfare gains/losses including the transition paths (first section, "including transition"). Total economy-wide welfare gains/losses are defined as $ce^{tot} = (1-\mu)ce^o + \mu^r$, where μ is the share of rule-of-thumb consumers.

cuts). Still, a tax wedge reduction in one country can entail small "beggar-thy-neighbor" effects.

7. Conclusions

Budget-neutral tax wedge reductions are one of the policy priorities in many EMU member states. By means of a New Keynesian DSGE model of a monetary union with a complex labor market structure and a comprehensive fiscal bloc, this paper assessed the macroeconomic and welfare implications of reductions in firms' and workers' labor tax rates financed by different fiscal policy measures. Overall, the paper showed that a reduction in the tax wedge is beneficial in terms of both welfare and output gains. While financing the labor tax wedge reduction by an increase in consumption taxation yielded most favorable output effects, financing it by a reduction in government spending was more welfare enhancing, as the latter does not imply a policy-induced increase in private consumption costs. Extending the insights of existing literature, the paper showed that a reduction in the workers' and not the firms' burden is most beneficial when firms can fully vary the intensive margin of labor demand to adjust to policy changes. When ignoring the intensive hours margin, however, the cost-reducing effect of lower social security contributions for firms dominates, in line with findings in the literature.

Appendix

In this appendix, we provide a more detailed formal analysis of the role of the search-and-matching labor market and of the introduction of an intensive labor hours margin for the impact of workers' personal income tax versus firms' social security contribution reductions on labor supply and demand (cf. section 5.1.2).

Formal Description

First, we will investigate the mechanism driving the labor market effects of a tax wedge reduction in more formal detail. For this purpose, we simplify the model presented in section 3.1 by assuming no liquidity-constrained consumers, $\mu = 0$, and no wage stickiness,

$\theta_w = \theta_w^n = 0$. We will only focus on steady-state comparisons. These assumptions highly simplify the exposition of the argument without loss of generality. Furthermore, we will proceed in four steps for the ease of understanding. Under the simplifying assumptions, equation (6) in steady state becomes

$$\bar{\Omega} = \frac{\xi}{1-\xi} \cdot \frac{1-\bar{\tau}^w}{1+\bar{\tau}^{sc}} \cdot \bar{J}. \tag{15}$$

In a *first step*, let us ignore public employment, the endogenous provision of hours worked, and the time variation in unemployment benefits by exogenously imposing $\bar{p}^g = \kappa^h = 0$, $\bar{l} = 1$, and $\bar{\kappa}^B$ to be fixed at some value. Then, after some algebra, the steady-state wage can be expressed as

$$\begin{aligned}(1-\bar{\tau}^w)(1+\bar{\tau}^{sc})\,\bar{w}^p = \xi\,(1-\bar{\tau}^w)\,\left[\bar{x} + \beta(1-s^p)\,\kappa^v \cdot \bar{\theta}^p\right] \\ +\,(1-\xi)\,(1+\bar{\tau}^{sc})\,\bar{\kappa}^B,\end{aligned} \tag{16}$$

where $\bar{\theta}^p = \bar{v}^p/\bar{\tilde{U}}$. Substituting into the job-creation condition, equation (9), and rearranging yields

$$[1-\beta(1-s^p)]\,\frac{\kappa^v}{q(\bar{\theta}^p)} + \beta(1-s^p)\,\xi\,\kappa^v\bar{\theta}^p = (1-\xi)\left[\bar{x} + \frac{1+\bar{\tau}^{sc}}{1-\bar{\tau}^w} \cdot \bar{\kappa}^B\right]. \tag{17}$$

It is straightforward to see that $d\bar{\theta}^p/d\bar{\tau}^w = \frac{1+\bar{\tau}^{sc}}{1-\bar{\tau}^w} \cdot d\bar{\theta}^p/d\bar{\tau}^{sc}$ and, because $\frac{1+\bar{\tau}^{sc}}{1-\bar{\tau}^w} > 1$, it must hold that $|d\bar{\theta}^p/d\bar{\tau}^w| > |d\bar{\theta}^p/d\bar{\tau}^{sc}|$. In words, this implies that, in our simple model, a labor income tax reduction on the workers' side will affect job creation more positively than a reduction of the social security contributions levied on firms. In principle, this already goes in the direction of what we find in our paper. However, from Pissarides (2000, p. 205), we know that, "in general, tax incidence is independent of who pays the tax," while we find that this is not the case here.

In order to solve this alleged contradiction, let us, in a *second step*, allow for time variation in unemployment benefits by assuming that $\kappa_t^B = rrs\,(1-\tau_{t-1}^w)\,w_{t-1}$, as we also do in our model. In this case, we get

$$(1-\bar{\tau}^{w})\,(1+\bar{\tau}^{sc})\,(1-(1-\xi)rrs)\,\bar{w}^{p} \\ = \xi\,(1-\bar{\tau}^{w})\,\left[\bar{x}+\beta(1-s^{p})\,\kappa^{v}\cdot\bar{\theta}^{p}\right] \tag{18}$$

as the steady-state wage, which, after substituting in the job-creation condition and rearranging, yields

$$[1-\beta(1-s^{p})]\,[1-rrs(1-\xi)]\,\frac{\kappa^{v}}{q(\bar{\theta}^{p})}+\beta(1-s^{p})\,\xi\,\kappa^{v}\bar{\theta}^{p} \\ = (1-\xi)\,(1-rrs)\cdot\bar{x}. \tag{19}$$

Clearly, it no longer plays a role who pays taxes. As Pissarides (2000, chapter 9) has shown, what matters for job creation is the tax level itself—governed by the parameter rrs in our simplified model—but not who pays the tax. This finding is reconciled in equation (19) and depends on the assumption that unemployment benefits are a fraction of net wages received by workers, which is also the underlying assumption driving the result in Pissarides (2000). The difference to the situation after the first step when assuming fixed unemployment benefits in equation (17) is the following. In the first situation, the relative value of employment over unemployment is affected more by the workers' labor tax rate than by the social security contribution rate due to different effects on the workers' outside option in the bargaining process.[13] Hence, changes in the labor income tax rate will, in this situation, have a larger effect on job creation and it will, then, matter who actually pays the tax. This no longer matters when unemployment benefits are some fraction of net wages.

Even though our model includes time-varying unemployment benefits, simulations still show that results clearly depend on who has to pay the tax. In order to explain why this is the case, let us include public employment into this section's analysis as a *third step.* In this case, we get

$$(1-\bar{\tau}^{w})\,(1+\bar{\tau}^{sc})\left(1-(1-\xi)rrs\left(1-\frac{\beta(1-s^{p})\bar{p}^{g}}{1-\beta(1-s^{g})(1-\bar{p}^{g})}\right)\right)\bar{w}^{p} \\ = \xi\,(1-\bar{\tau}^{w})\,\left[\bar{x}+\beta(1-s^{p})\,\kappa^{v}\cdot\bar{\theta}^{p}\left(1+\frac{\beta(1-s^{p})\bar{p}^{g}}{1-\beta(1-s^{g})(1-\bar{p}^{g})}\right)\right]$$

[13]This holds unless $(1+\bar{\tau}^{sc})=(1-\bar{\tau}^{w})^{-1}$, which is not the case in our model and, most likely, not in reality.

$$+ (1-\xi)\frac{\beta(1-s^p)\bar{p}^g}{1-\beta(1-s^g)(1-\bar{p}^g)}(1-\bar{\tau}^w)\left(1+\bar{\tau}^{sc}\right)\bar{w}^g, \tag{20}$$

where use has been made of the workers' marginal utility of being employed in the public sector, H_t^g, the latter evaluated at steady state. It is straightforward to see that a higher wage rate in the public sector, $\bar{w}^g$—as well as a higher probability of finding a job in the public sector, $\bar{p}^g$—augments wages workers demand in private-sector wage negotiations. The reason is that the possibility of finding a job in the public sector increases the workers' fallback utility. Substituting the wage resulting from taking into account public employment, equation (20), into the job-creation condition yields

$$\begin{aligned}
&[1-\beta(1-s^p)]\left(1-(1-\xi)rrs\left(1-\frac{\beta(1-s^p)\bar{p}^g}{1-\beta(1-s^g)(1-\bar{p}^g)}\right)\right)\frac{\kappa^v}{q(\bar{\theta}^p)}\\
&\quad+\beta(1-s^p)\,\xi\,\kappa^v\bar{\theta}^p\left(1+\frac{\beta(1-s^p)\bar{p}^g}{1-\beta(1-s^g)(1-\bar{p}^g)}\right) \qquad (21)\\
&=(1-\xi)\left(1-rrs\left(1-\frac{\beta(1-s^p)\bar{p}^g}{1-\beta(1-s^g)(1-\bar{p}^g)}\right)\right)\\
&\quad\cdot\bar{x}-(1-\xi)\frac{\beta(1-s^p)\bar{p}^g\cdot(1+\bar{\tau}^{sc})\,\bar{w}^g}{1-\beta(1-s^g)(1-\bar{p}^g)}.
\end{aligned}$$

Formally, we immediately see from equation (21) that $|d\bar{\theta}^p/d\bar{\tau}^w|=0$, whereas $|d\bar{\theta}^p/d\bar{\tau}^{sc}|>0$. In words, this means that, when taking into account public employment—still ignoring the endogenous provision of hours worked—a tax wedge reduction using social security contributions levied on firms is more favorable than reducing the workers' labor income tax rate. This is also what we found in the full model when ignoring hours worked.

After the second step in our simplified model, we saw that it makes no difference who pays taxes when assuming time-varying unemployment benefits. The argument is analogous when decreasing the workers' personal income tax rate while, at the same time, taking into account public employment. The reason is that the decrease in $\bar{\tau}^w$ affects steady-state utility of being employed in the private or the public sector in the same direction and by the same relative amount. Hence, the relationship between the workers' steady-state utilities and fallback utilities remains constant. On the contrary, for given public wages and public employment, an increase in social security contributions on the firms' side only reduces job-creation incentives in the private sector, which makes public employment relatively more attractive and increases the workers' fallback utility (in relative terms). Hence, when ignoring the intensive hours margin, the fact that reductions in the firms' social security contributions generate more favorable effects is driven by lowering the relative attractiveness of public-sector employment and, thereby, producing a reduced fallback position of workers.

In a last step, we now also take into account the intensive hours margin. Given that hours in the public sector are assumed to be an exogenous policy variable, we ignore it in the following exposition for the sake of brevity. However, including hours worked in the private-sector bargaining, we need to add $(1-\xi)(1+\bar{\tau}^{sc})\kappa^h/\left(\bar{\lambda}(1+\sigma_h)\right)\bar{l}^{p\,1+\sigma_h}$ to the right-hand-side of equation (20), where $\bar{\lambda}=\left(\bar{c}^{\sigma_c}(1+\bar{\tau}^c)\right)^{-1}$ is households' marginal utility of consumption. Substituting into the job-creation condition, we know that we need to add $-(1-\xi)(1+\bar{\tau}^{sc})/(1+\bar{\tau}^w)\kappa^h/\left(\bar{\lambda}(1+\sigma_h)\right)\bar{l}^{p\,1+\sigma_h}$ there in order to take into account endogenous hours worked in the private sector. Deriving this latter term with respect to $\bar{\tau}^w$ and $\bar{\tau}^{sc}$ implies that, from the perspective of the intensive hours margin, a reduction in the workers' personal income tax rate yields higher incentives for additional job creation as a reduction in firms' social security contributions. The argument is analogous to the one made after the first step, where we had exogenously given unemployment benefits.

Hence, a labor tax wedge reduction by means of a PIT or SSC decrease now entails a tradeoff in the workers' fallback utility. Depending on which instrument is used, it either makes public employment less attractive in relative terms (see equation (21)) or it decreases the relative disutility of labor supply more strongly. Which effect dominates depends on how these two elements in the fallback position of the worker are related. Furthermore, we know from the hours bargaining condition, equation (8) evaluated at steady state, that $|d\bar{l}^p/d\bar{\tau}^w|=\frac{1-\bar{\tau}^{sc}}{1+\bar{\tau}^w}\cdot|d\bar{l}^p/d\bar{\tau}^{sc}|$. This implies that a reduction in the personal income tax rate fosters the provision of (additional) working hours more than a reduction in the firms' social security contribution rate. Therefore, the tradeoff is tilted towards a reduction in the workers' personal income tax rate when taking into account the additional hours margin. Our simulations show that, in the full model, this effect overcompensates for the public employment effect when hours are taken into account.

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