Labor market reforms and current account imbalances - beggar-thy-neighbor policies in a currency union?

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Abstract

Member countries of the European Monetary Union (EMU) have initiated wide-ranging labor market reforms in the last decade. This process is ongoing, as countries that are faced with serious labor market imbalances perceive reforms as the fastest way to restore competitiveness within a currency union. This fosters fears among observers about a beggar-thy-neighbor policy that leaves non-reforming countries with a loss in competitiveness and an increase in foreign debt. Using a two-country, two-sector search and matching DSGE model, we analyze the impact of labor market reforms on the transmission of macroeconomic shocks in both non-reforming and reforming countries. By analyzing the impact of reforms on foreign debt, we contribute to the debate on whether labor market reforms increase or reduce current account imbalances.

Keywords: Current account deficit, labor market reforms, DSGE models, search and matching labor market
JEL Classifications: E24, E32, J64, F32

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1. Introduction

During the first decade after the creation of the European Monetary Union (EMU), a number of member states initiated wide-ranging labor market reforms. These reforms tend to have stabilized output and employment during the economic and financial crises. For this reason, countries that are faced with serious labor market imbalances, perceive reforms as the fastest way to restore competitiveness. Some observers, nevertheless, see labor market reforms embodying a beggar-thy-neighbor policy[1], leaving non-reforming countries with reduced competitiveness and increasing foreign debt which exacerbates macroeconomic imbalances within the currency union. Using a two-country, two-sector DSGE model with search and matching frictions, we derive the impact of labor market reforms not only on steady-state output, employment and average real wages but also on the transmission of macroeconomic shocks and the appearance of foreign debt in non-reforming countries. This should contribute to the debate on whether labor market reforms do indeed embody a beggar-thy-neighbor policy or rather add to macroeconomic stability within the union.

The major problem faced in the 1990s by some of today's EMU member states was encompassed in the double-digit unemployment rates (Dreze and Malinvaud, 1994; Bean, 1994; Layard, Nickell, and Jackman, 1994; Lindbeck, 1996; Phelps, 1994). Because of labor market inflexibility, an increase in growth no longer contributed to a strong rise in employment (Salvatore, 1998). Labor market reforms should, therefore, increase flexibility towards job-rich growth. By the mid-2000s, a number of EMU members had begun implementing these reforms. Austria, Germany, Greece, France and Slovakia reduced the replacement rate[2] significantly (by between 12.7 and 22.3 percentage points). Some countries such as Germany shifted resources from passive to active labor market policies, intending to increase the efficiency of the labor market matching process. Furthermore, a significant number of countries trimmed down regulations for temporary agency work, which then doubled in the following years in Austria, Germany and Denmark and, in the last decade, tripled in Italy and Finland.[3] Since some countries that imposed reforms in the 2000s were now experiencing lower unemployment, higher output stability and less foreign debt, as compared with their non-reforming counterparts, the contribution of labor market reforms to competitiveness and the current account became a controversial subject of discussion.

In principle, there are two different approaches which can be used to analyze the link between labor market reforms and the current account balance. Most

[1] Felbermayr, Larch, and Lechthaler (2012) demonstrate the economic rationale of this debate using traditional trade models and provide arguments for why this must not hold in modern trade theory.

[2] The replacement rate is the percentage of a workers pre-unemployment income paid out by an unemployment insurance company or as welfare upon the transition from work to unemployment.

[3] Carone, Pierini, Stovicek, and Sail (2009) provide an excellent overview of labor market reforms in Europe

papers follow a direct approach that treats structural reforms as macroeconomic shocks. There are at least three competing theories which, in this context, explain why structural reforms, in particular labor market reforms, directly influence the current account. The first sees structural reforms beeing painful today but promising future gains (Obstfeld and Rogoff, 1995). It would, therefore, be rational for countries to borrow today in order to be compensated for the current pain of structural reforms. Hence, the current account balance should decline in the short run. But since any future gains from structural reforms will be used to pay back the loans, we should observe a reversal and a positive current account surplus in the future. However, future returns of reforms are uncertain.

Another argument concerning the impact of structural reforms on current account balances has been propagated by Kennedy and Slok (2005). They argue that initially wages and prices decline as a result of reforms. Hence, the country experiences a price advantage and so exports increase and imports decline. As a result, the current account balance improves in the short run, profitability increases with a time lag and the internal interest rate also increases, investment goes up and foreign capital is attracted which, in turn, tends to reduce capital exports and, therefore, goods exports. In the long run, the current account surplus should thus decline. Bertola and Lo Prete (2009) analyze the effects of rising income growth and income risk as a result of labor market deregulation. They argue in the same way as Kennedy and Slok (2005) that labor market deregulation should improve the current account balance of the reforming country without much delay, since forward-looking individuals increase their precautionary savings in view of a higher uninsurable risk.

A third explanation for rising current account balances is that purchasing power shifts towards individuals with higher saving propensities. Hence, the impact of structural reforms on the current account balance is a priori not clear, and disputed in the empirical literature. In this context, Kennedy and Slok (2005) analyze the role of structural policy reforms in the solution of global current account imbalances in fourteen OECD countries. They find a significant but small contribution of structural policy indicators to explain current account positions. Chen, Milesi-Ferretti, and Tressel (2013), however, doubt a strong contribution of labor market reforms, arguing that the presence of asymmetric shocks leads to strong current account imbalances, not the reform shock itself.

If reforms are here to stay, they should be implemented as a change in the institutional setting affecting macroeconomic stability rather than as a shock. In this paper, we follow this indirect approach and treat labor market reforms as a change in the characteristics of a steady-state. This adds to an already growing body of literature analyzing the impact of labor markets reforms on stability. In a closed economy model, Zanetti (2011) shows the impact of decreasing replacement rates and firing costs on the stability of the economy and Krause and Uhlig (2012) discuss the effect of labor market reforms in the presence of shocks to the discount factor. Mussa (2005) argues that structural reforms affect the adjustment capacity of the currency union as a whole. Therefore, external balances will more easily readjust in the wake of shocks in general, such as the introduction of the single currency or of asymmetric shocks manifesting themselves in divergent, country-specific competitiveness positions. This view goes far back to the seminal paper by Mundell (1961) on optimum currency areas, as well as to more recent research, such as Pissarides (1997) or Blanchard (2007). In this context, the application of supply-side-oriented measures (which directly lower the natural rate of unemployment) lowers the magnitude of the demand shock necessary to reverse the effect of an adverse shock in the past ("coercive power" in the language of ferromagnetics Blanchard and Summers (1987)). Positive demand shocks lower the "remanence" of past shocks. In other words, institutions which can be modified by reforms serve as propagation mechanisms for shocks (Blanchard and Wolfers, 2000). While the impact of labor market reforms in the context of macroeconomic shocks receives increasing attention, up to now research on the influence of labor market reforms on the current account is scarce. In this context, and relating to the EMU, we see essentially two open questions: do labor market reforms, in the presence of macroeconomic shocks, raise the current account deficit of non-reforming countries, as a faster adjustment in some countries weakens the adjustment process of others? Or do flexible labor markets, in general, help to absorb shocks more swiftly, which also benefits non-reforming countries?

The contribution of this paper is to provide a two-county two-sector DSGE model with search and matching frictions. This allows us to identify the contribution of different labor market reform measures to the current account deficit of non-reforming countries. Naturally, our model is not the first to address labor market frictions in a DSGE framework. Zanetti (2011) and Walsh (2005) use a similar approach to include labor markets, while Krause and Uhlig (2012) analyze the German reduction of the replacement rate by employing a model with different skill groups to focus on the impact of labor market reforms on high-skilled versus low-skilled workers. Krause and Lubik (2007), on the other hand, introduce real wage rigidities into a New Keynesian modeling framework distinguishing between sectors with high and low productivity. In addition to previous models, we follow Obstfeld and Rogoff (2007) and Ferrero, Gertler, and Svensson, Lars E. O. (2008) to include trade, international borrowing and preferences for the consumption of home tradables into a DSGE model with search and matching frictions. In this setting, households adjust consumption according to differences in the terms of trade so that international borrowing gives rise to a current account deficit or surplus. As the labor market stance has an influence on prices and productivity, reforms can have an impact on net exports and the current account. The remainder of this paper is organized as follows. The following section introduces the model; the third section describes the calibration of the model to a typical EMU member state; the fourth section presents the steady-state results, the reaction of the model to differing shocks, and some robustness checks. The fifth section concludes.

2. The model

We build a two-country, two-sector currency union model with search and matching frictions in which a representative household maximizes lifetime utility according to the rational expectations hypothesis. In each period the household faces the decision of whether to buy tradables from the domestic or the foreign economy, to buy non-tradables, to hold real money balances or to postpone consumption until later by buying bonds. Foreign and domestic tradable as well as non-tradable consumption goods sold by retailers are subject to staggered price setting (Calvo, 1983). Following Andolfatto (1996) and Merz (1995), we include the assumption ofUzawa-type preferences . This preference specification allows the model to be stationary, in the sense that the non-stochastic steady state is independent of initial conditions (Schmitt-Grohé and Uribe, 2003). Furthermore, the steady-state is always unique even in the presence of low elasticities of substitution between the tradable good bundles of the two countries (Bodenstein, 2011). There are two sectors of production in each country. Each sector be divided into two types of economic entities, firms which produce intermediate goods and retailers. The trade specification of the model resembles that of Obstfeld and Rogoff (2007) and, more specifically, Ferrero, Gertler, and Svensson, Lars E. O. (2008), with the exception that we impose staggered price setting on the level of the retailers (Bernanke, Gertler, and Gilchrist, 1999) rather than on the level of the firms. Furthermore, we assume a search and matching labor market with endogenous separations rather than staggered wage setting.[4]

The preferences of households are expressed by a nested utility function combining, on the one hand, non-tradables and tradables using a Cobb-Douglas function and, on the other, tradables from the domestic and foreign economies using a CES specification. This setting is specified in a way which reflects the fact that households have a preference for domestically produced products. Additionally, the assumption of a home bias gives rise to a “transfer effect”, as Obstfeld and Rogoff (2007) call it, according to which a country sees a deterioration in its terms of trade if national expenditures decline.

In both sectors of the economy we have nominal price rigidities. Given irrevocably fixed exchange rates due to our currency union setting, prices for tradable goods are identical in both countries. In a steady-state equilibrium, trade is always balanced. During adjustments following macroeconomic shocks, it might, nevertheless, be favorable for households in a given country to increase imports and run up debt. Financial markets are assumed to be imperfect in the sense that only the bond of the domestic country is internationally tradable.

In our model, labor is, at least in the short run, not mobile between the two countries. As a result, the imbalances that arise are more persistent than they would be in a model with factor mobility. We use this assumption as we believe that there is still a long way to go before we see full factor mobility within the Eurozone materializing (Krause, Rinne, and Zimmermann, 2014) so that, given the scope of this paper, closed labor markets might be a reasonable approximation.

More specifically, the labor markets in our model build on the search and

[4]Both deviations enable us to analyze labor market reforms as we include search and matching frictions and endogenous job-separations.

matching model with endogenous job destruction developed by Mortensen and Pissarides (1994), in which a worker and a firm in each period have to decide whether to preserve or to terminate their relationship. Following Zanetti (2011), Krause and Lubik (2007) and Walsh (2005), we embed the labor market specification of the Mortensen-Pissarides model of den Haan, Wouter J., Ramey, and Watson (2000) in a New Keynesian setting.

In each period, unemployed workers search for a job and intermediate goods-producing firms want to fill their vacancies. The matching function describes the process of generating job matches by combining unemployed workers with open vacancies. In contrast to Krause and Uhlig (2012), where a new match can have an idiosyncratic productivity below the threshold level[5], we assume that the productivity of a new worker is always higher than the threshold. When a match is generated, wage bargaining starts. After the firm and the worker have agreed on a specific wage training starts, enabling the match to become productive in the next period. At the beginning of each period, firm and workers are forced to separate with a given probability owing to disturbances exogenous to the model. If a match survives exogenous separations, the firm is still able to choose to post a vacancy or to keep the employee. As there are vacancy posting and firing costs for firms as well as search costs for workers, continuing a match might generate a surplus. This surplus occurs if firms and workers observe a productivity of the match that is above a threshold level at which the surplus is zero. Firms that have an open position post vacancies as long as the value of the vacancy is greater than zero. If the number of vacancies increases, however, the probability of finding a convenient match diminishes. This results in a reduction in the expected value of an open position. In equilibrium, free market entry ensures that the value of a vacancy is always zero.

To sum up, the model economy is characterized by nominal rigidities in the goods market and search and matching frictions in the labor markets. It consists of a representative household, a production sector comprised of representative intermediate goods-producing firms and a continuum of retail firms, indexed by i, with $i \in [0, 1]$, as well as a central bank for the monetary union.

2.1. The representative household

Our economy is inhabited by a large number of infinitive living identical households consuming aggregates of domestic and imported monopolistic goods (Dixit and Stiglitz, 1977). Owing to labor market search frictions, any household is either employed or unemployed. In general, labor is supplied inelastically. As a second source of income, households own shares in domestic firms and receive dividends D_t from them. We assume that households in the domestic economy and in the foreign country have the same preferences and endowments, defined over a composite consumption good C_t and real money holdings M_t/P_t. As described by Merz (1995), we assume a perfect insurance system where

[5]The threshold productivity defines a specific idiosyncratic productivity, where a firm is indifferent between continuing or separating a match.

households can insure themselves against variations in income. This assumption removes heterogeneity among households within a given country and enables us to consider the optimization problem of a representative household maximizing expected lifetime utility. During each period $t = 0, 1, 2, \ldots$, the expected lifetime utility function is given by

$$E \sum_{t=0}^{\infty} \beta_t \left[\ln C_t + \kappa_m \ln \left(\frac{M_t}{P_t} \right) \right], \tag{1}$$

where $\beta_t = \frac{e^{\varsigma_t}}{1+\psi(\ln C_t - \vartheta)} \beta_{t-1}$ for $t \geq 0$, $\beta_0 = 1$ represents the endogenous discount factor and κ_m denotes a scaling parameter for utility from real money holdings with $\kappa_m > 0$. The consumption index C_t is defined as

$$C_t \equiv \frac{C_{Tt}^{\iota} C_{Nt}^{1-\iota}}{\iota(1-\iota)}. \tag{2}$$

Tradable goods $C_{T,t}$ can be obtained from the domestic $C_{H,t}$ or from the foreign economy $C_{F,t}$ while non-tradables $C_{N,t}$ are produced at home, only. Following Ferrero, Gertler, and Svensson, Lars E. O. (2008), we employ a Cobb-Douglas[6] specification with ι as the proportion of total expenditure devoted to tradable goods.

$$C_{T,t} = \left[\alpha^{\frac{1}{\gamma}} C_{H,t} + (1-\alpha)^{\frac{1}{\gamma}} C_{F,t}^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \tag{3}$$

In this specification, γ measures the elasticity of substitution between home and foreign goods and α is the share parameter of the CES-function. Household demand is derived by minimizing costs for the specific goods bundles.

$$C_{H,t} = \alpha \left(\frac{P_{T,t}}{P_{H,t}} \right)^{\gamma} C_{T,t} \quad C_{F,t} = (1-\alpha) \left(\frac{P_{T,t}}{P_{F,t}} \right)^{\gamma} C_{T,t} \tag{4}$$

$$C_{N,t} = (1-\iota) \frac{P_t}{P_{N,t}} C_t \quad C_{T,t} = \iota \frac{P_t}{P_{T,t}} C_t$$

A household chooses consumption, nominal money and bond holdings subject to a budget constraint of the form

$$P_t C_t + B_t / R_t + M_t = B_{t-1} + P_t Y_t + D_t + \varrho_t + M_{t-1}, \tag{5}$$

for $t = 0, 1, 2...$, where P_t denotes the price of a bundle of domestic tradable and non-tradable and foreign tradable goods. At the beginning of period t, the household receives a lump-sum transfer ϱ_t from the central bank and dividends

[6] We assume a unit elasticity between non-traded and traded goods which is typical but not undisputed in the literature. Based on the simulations of Obstfeld and Rogoff (2005) with an unit elasticity, a elasticity of two and one of 100, we don't expect a strong impact of the elasticity on our simulation results.

D_t from the representative intermediate-goods-producing firm. Total income amounts to Y_t. The household enters period t with bonds B_{t-1} and M_{t-1} units of money. Furthermore, the mature bonds providing additional B_{t-1} units which are all sold at the beginning of the period and might be used to purchase B_t new bonds at the nominal cost B_t/R_t with R_t as the nominal interest rate between t and $t+1$. Solving the intertemporal optimization problem, we derive the following first-order conditions:

$$\Lambda_t = C_t^{-1} \tag{6}$$

$$E_t \beta_{t,t+1} = E_t \frac{\pi_{t+1}}{R_t} \tag{7}$$

$$\frac{\kappa_m}{m_t} = \Lambda_t - \beta_t E_t \frac{\Lambda_t}{\pi_{t+1}}, \tag{8}$$

where $\beta_{t,t+1} = \beta_t \Lambda_{t+1}/\Lambda_t$ is the stochastic discount factor. The parameter ψ is assumed to be small, the endogeneous discount factor is β_t and the shock term is ς_t. Real money holdings are defined as $m_t = M_t/P_t$. Combining the first-order conditions with respect to C_t and B_t, (6) and (8), yields the standard consumption Euler equation:

$$\beta_t E_t \left(\frac{C_{t+1}}{C_t}\right)^{-1} = E_t \frac{P_{t+1}}{R_t P_t}. \tag{9}$$

We distinguish three different statuses of employment the representative household: let U_t, $W_{j,t}^N$ and $W_{j,t}(a_t)$ denote respectively the present discounted value of an unemployed, newly employed and continuously employed worker, with j being an index for the two sectors of each economy. In case of unemployment, the worker enjoys a real return b and expects to move into employment with probability $p_j(\theta_{j,t})$, becoming employed either in the tradable or in the non-tradable sector. Therefore, the present discounted income stream of an unemployed worker is

$$U_t = b + E_t \beta_{t,t+1} \left[\sum_{j=1}^{2} p_j(\theta_{j,t}) W_{j,t+1}^N + (1 - \sum_{j=1}^{2} p_j(\theta_{j,t})) U_{t+1} \right]. \tag{10}$$

Following Pissarides (2000) , the flow value of being unemployed, $b = h + \rho_w w$, consists of the value of home production or leisure h and unemployment benefits $\rho_w w$, where ρ_w represents the replacement ratio with $0 < \rho_w < 1$ and w the steady-state average wage. The second part of Equation (10) describes the expected capital gain from a change of state.

The worker's value from holding a job with match productivity $a_{j,t}$ is given by

$$
\begin{aligned}
W_{j,t}(a_{j,t}) &= w_{j,t}(a_{j,t}) \\
&+ E_t\beta_{t,t+1}\left[(1-\rho^x)\int_{\mathring{a}_{j,t+1}}^{\infty} W_{j,t+1}(a_{j,t+1})dF(a_{j,t+1}) + \rho_{j,t+1}U_{t+1}\right].
\end{aligned} \tag{11}
$$

Equation (11) tells us that an employed worker is paid a sector-specific wage $w_{j,t}(a_{j,t})$, and that if he or she survives exogenous and endogenous job destruction, which happens with a total probability of ρ_{t+1}, the match will start to produce goods.

The present-discounted value of a new match is

$$
\begin{aligned}
W^N_{j,t} &= w^N_{j,t} \\
&+ E_t\beta_{t,t+1}\left[(1-\rho^x)\int_{\mathring{a}_{j,t+1}}^{\infty} W_{j,t+1}(a_{j,t+1})dF(a_{j,t+1}) + \rho_{j,t+1}U_{j,t+1}\right].
\end{aligned} \tag{12}
$$

Please note, that Equation (12) differs from (11) in the wages of new workers, only. The wages of new workers, $w^N_{j,t}$, will be different from those of continuing workers, $w_{j,t}(a_{j,t})$ owing to the presence of firing costs that a firm has to bear if it decides to fire a worker. As in the first period no endogenous job destruction takes place, firing costs in this period do not influence the wages of new workers.

2.2. Labor market matching

During each period $t = 0, 1, 2, \ldots$, an intermediate goods-producing firm posts a vacancy or continues the match from the previous period. Each single job has the status filled or vacant. Because of matching frictions, it is assumed that the process of job search and hiring is time-consuming and costly for both the worker and the firm. If a firm finds a suitable worker, both form a match. The number of job matches depends on the matching function $m_{j,t}(u_{j,t}, v_{j,t})$, where $v_{j,t}$ denotes the number of vacancies in both sectors of the economy, home-produced tradable and non-tradable goods $j = H, N$, and $u_{j,t}$ is the number of unemployed workers searching in sector j. We assume a Cobb-Douglas matching function

$$
m_{j,t}(u_{j,t}, v_{j,t}) = \chi u^{\xi}_{j,t} v^{1-\xi}_{j,t}, \tag{13}
$$

where $0 < \xi < 1$ and χ is scale parameter reflecting the efficiency of the matching process. Defining labor market tightness as $\theta_{jt} = v_{j,t}/u_{j,t}$ and making use of the CRS property of $m_{j,t}$, we write the job-finding probability in sector j for an unemployed worker as

$$
p(\theta_{j,t}) = m_{j,t}(u_{j,t}, v_{j,t})/u_{j,t} = \chi\theta^{1-\xi}_{j,t}, \tag{14}
$$

and the probability that a searching firm in this sector will find a worker as

$$q(\theta_{j,t}) = m_{j,t}(u_{j,t}, v_{j,t})/v_{j,t} = \chi\theta_{j,t}^{-\xi}. \quad (15)$$

The tighter the labor market, the easier it is for unemployed workers to find a job. Equation (15) implies that the higher the number of vacancies v_{jt} for a given number of unemployed workers searching in this sector, $u_{j,t}$, the more difficult it is for firms to fill vacant positions.

At the beginning of any period t, job separations take place as a result of an exogenous negative shock with probability ρ_j^x. Firm and worker may decide to dissolve a match endogenously if the realization of the worker's idiosyncratic productivity of $a_{j,t}$ is below a certain threshold productivity $\mathring{a}_{j,t}$. The probability of endogenous job destruction is given by $\rho_{j,t}^n = P(a_{j,t} < \mathring{a}_{j,t}) = F(\mathring{a}_{j,t})$. The total job separation rate, therefore, is $\rho_{j,t} = \rho_j^x + (1-\rho_j^x)\rho_{j,t}^n$. As in den Haan, Wouter J., Ramey, and Watson (2000), the idiosyncratic productivity $a_{j,t}$ is drawn from a log-normal distribution with mean μ_{ln} and standard deviation σ_{ln}.

Following Mortensen and Pissarides (1994), new matches have a productivity of $a_{j,t}^N$, which ensures that their productivity is always above the productivity threshold $\tilde{a}_{j,t}$, and that all jobs produce before being destroyed. New matches in t, $m_{j,t}$, become productive for the first time in $t+1$. Consequently, the employment in each sector evolves according to $n_{j,t} = (1-\rho_{j,t})n_{j,t-1} + m_{j,t-1}(u_{j,t-1}, v_{j,t-1})$. As we normalize total employment to unity, the sum of unemployed persons becomes $u_t = \left(1 - \sum_{j=1}^{2} n_{j,t}\right)$.

The representative intermediate goods-producing firm

If an intermediate goods-producing firms posts a vacancy, it bears costs c_j. Labor is the only input in the production function. At the beginning of each period, old and new matches draw an idiosyncratic, job-specific productivity $a_{j,t}$. Production in each sector is subject to an aggregate productivity shock, $A_{j,t}$, common to all firms. If the realization of a worker's idiosyncratic productivity is above the reservation productivity $\mathring{a}_{j,t}$, the firms will produce output using labor $y_{j,t} = A_{j,t}a_{j,t}$. The aggregate productivity $A_{j,t}$ follows an AR(1) process, $\ln(A_{j,t}) = \rho_{Aj}\ln(A_{j,t-1}) + \epsilon_{Aj}$, where ρ_{Aj} is the serial correlation coefficient with $0 < \rho_{Aj} < 1$ and ϵ_{Aj} follows a white noise process with standard deviation σ_{Aj}.

We define the present discounted value of expected profits from a vacant job as follows:

$$V_{j,t} = -c_j + E_t\beta_{t,t+1}\left[q_j(\theta_{j,t})J_{j,t+1}^N + (1-q_j(\theta_{j,t}))V_{j,t+1}\right]. \quad (16)$$

With a probability of $q_j(\theta_{j,t})$, the firms matches with a worker and the match yields a return of $J_{j,t+1}^N$. With a probability of $1-q_j(\theta_{j,t})$, the job remains vacant with a return of $V_{j,t+1}$. As long as the value of a vacancy is greater than zero, a firm will post new vacancies. In equilibrium, free market entry drives the profit from opening a vacancy to zero, which implies $V_{j,t} = 0$ for any t. This yields the vacancy posting condition

$$\frac{c_j}{q_j(\theta_{j,t})} = E_t \beta_{t,t+1} J^N_{j,t+1}, \tag{17}$$

which states that the expected cost of hiring a worker, $c_j/q_j(\theta_{j,t})$, is equal to the expected profit generated by a new match.

The value of a newly hired worker enjoyed by a firm is given by

$$\begin{aligned} J^N_{j,t} = & \; mc_{j,t}\frac{P_{j,t}}{P_t}A_{j,t}a^N_{j,t} - w^N_{j,t} \\ & + E_t\beta_{t,t+1}(1-\rho^x_j)\left[\int_{\mathring{a}_{j,t+1}}^{\infty} J_{j,t+1}(a_{j,t+1})dF_j(a_{j,t+1}) - F_j(\mathring{a}_{j,t+1})T_j\right], \end{aligned} \tag{18}$$

where mc_j denotes the sector-specific real marginal costs of providing one additional unit of output. We distinguish between endogenous and exogenous separations. With probability $1-\rho^x_j$, the worker survives exogenous job destruction. For a surviving match, a realization of the idiosyncratic productivity below the critical threshold $\mathring{a}_{j,t+1}$ leads to endogenous separation and the firm incurs firing costs T_j.

Similarly, the present discount value of a continuing job with productivity $a_{j,t}$ to the employer is

$$\begin{aligned} J_{j,t}(a_{j,t}) = & \; mc_{j,t}\frac{P_{j,t}}{P_t}A_{j,t}a_{j,t} - w_{j,t}(a_{j,t}) \\ & + E_t\beta_{t,t+1}(1-\rho^x_j) \\ & \cdot\left[\int_{\mathring{a}_{j,t+1}}^{\infty} J_{j,t+1}(a_{j,t+1})dF_j(a_{j,t+1}) - F_j(\mathring{a}_{j,t+1})T_j\right] \end{aligned} \tag{19}$$

In Equations (18) and (19) the term $mc_{j,t}\frac{P_{j,t}}{P_t}A_{j,t}a_{j,t} - w_{j,t}(a_{j,t})$ represents the net return of a match, and $J_{j,t+1} - F_j(\mathring{a}_{j,t+1})T_j$ represents the present discounted firm surplus, if the match is not destroyed.

In this model, an expression for the real marginal cost $mc_{j,t}$ can be derived by using Equation (11) and the condition that a firm is indifferent between continuing a match and separating from the worker, $J_{j,t}(a^{\circ}_{j,t}) + T_j = 0$ (Mortensen and Pissarides, 2003). Combining these two equations and solving for $mc_{j,t}$, we obtain:

$$mc_{j,t} = \left(\begin{array}{c} w_{j,t}(\mathring{a}_{j,t}) - T_j \\ -E_t\beta_{t,t+1}(1-\rho^x)\left[\begin{array}{c} \int_{\mathring{a}_{j,t+1}}^{\infty} J_{j,t+1}(a_{j,t+1})dF_j(a_{j,t+1}) \\ -F_j(\mathring{a}_{j,t+1})T_j \end{array}\right] \end{array} \right)^{\frac{P_t}{P_{j,t}A_{j,t}\mathring{a}_{j,t}}} \tag{20}$$

From Equation (20), it can be seen that the real marginal costs amount to the wage minus the the firing costs and the expected future return generated by the match, weighted by the marginal product of labor. As pointed out by Trigari (2009), the real marginal costs are, in the presence of search and matching frictions, not equal to the wage divided by the marginal product of labor. Instead, they also depend on the expected present-discounted payoff of preserving a match, which internalizes the firing costs.

Wage bargaining

In each period, firms and workers bargain over the real wage for that period, regardless of whether they form a continuing or a new match. The wage is set according to Nash bargaining. The worker and the firm share the joint surplus and the worker receives the fraction $\eta \in [0, 1]$. Since the wage depends on the idiosyncratic productivity of the worker, the wage bargaining rules for continuing and new matches are given by

$$\eta(J_{j,t}(a_{j,t}) + T_j) = (1 - \eta)(W_{j,t}(a_{j,t}) - U_t), \tag{21}$$

and

$$\eta J^N_{j,t}(a_{j,t}) = (1 - \eta)(W^N_{j,t} - U_t), \tag{22}$$

respectively. The bargaining rule for continuing workers, represented by Equation (21), internalizes firing costs T_j, whereas new workers are not subject to firing costs because in the period they are hired their idiosyncratic productivity a^N_{jt} is assumed to be above the critical threshold $\mathring{a}_{jt}$.

We can now derive the wage for continuing workers using the Bellman equations (10)-(13), (15)-(16) and the bargaining rules for continuing and new matches, (17) and (18)

$$w_{j,t}(a_{j,t}) = \eta \left[mc_{j,t} \frac{P_{j,t}}{P_t} A_{j,t} a_{j,t} + c_j \theta_{j,t} + (1 - \zeta_{j,t}) T_j \right] + (1 - \eta) b. \tag{23}$$

The agreed wage for new workers is equal to

$$w^N_{jt} = \eta \left[mc_{j,t} \frac{P_{j,t}}{P_t} A_{j,t} a^N_{j,t} + c_j \theta_{j,t} - \zeta_{j,t} T_j \right] + (1 - \eta) b, \tag{24}$$

where $\zeta_{j,t} = E_t \beta_{t,t+1}(1 - \rho^x_j)$.
The wages that new and continuing workers receive consist of two elements. First, if firms have complete bargaining power, the bargained wage will equal the benefits from unemployment b, which includes unemployment insurance payments and welfare captured by the replacement rate as well as the utility derived from not working. Second, if workers have complete market power, the wage will be the match revenue $mc_{j,t} \frac{P_{j,t}}{P_t} A_{j,t} a_{j,t}$, plus the saved hiring costs, $c_j \theta_{j,t}$, minus the present discounted firing costs, $\zeta_{j,t} T_j$, and plus the savings on firing costs[7], T_j, in the case of continuing workers. In cases where the bargaining

[7] Firing costs are assumed to affect both endogenous and exogenous separations. The rational behind this assumption is that not all separations are driven by the individual productivity of a worker. Restructuring and orderly closures could be such reasons.

power of firms and workers is between these two extremes, the bargaining power of workers η attaches weight to the two elements. It follows from Equation (24) that the wage of new workers differs from those of continuing workers as they do not include firing costs related to endogenous job separations in the initial period.

2.3. Retail firms

We assume a continuum of monopolistic competitive retailers on the unit interval indexed by i. Each retailer purchases goods from intermediate goods-producing firms and transforms them into a differentiated retail good using a linear production technology. During each period $t = 0, 1, 2, \ldots$ a retailer j of sector $j = H, F, N$ sells $Y_{j,t}(i)$ units of the retail goods at the nominal price $P_{j,t}(i)$. Let $Y_{j,t}$ denote the composite of individual retails goods which is described by the CES aggregator of Dixit and Stiglitz (1977):

$$Y_{j,t} = \int_0^1 \left[Y_{j,t}(i)^{(\epsilon-1)/\epsilon} di\right]^{\epsilon/(\epsilon-1)}, \tag{25}$$

where ϵ with $\epsilon > 1$ is the elasticity of substitution across the differentiated retail goods. Then, the demand curve facing each retailer j is given by

$$Y_{j,t}(i) = \left[\frac{P_{j,t}(i)}{P_{j,t}}\right]^{-\epsilon} Y_{j,t}, \tag{26}$$

where $P_{j,t}$ is the aggregate price index of home-produced or foreign-produced tradable and non-tradable goods

$$P_{j,t} = \left[\int_0^1 P_{j,t}(i)^{1-\epsilon} dj\right]^{1/(1-\epsilon)}, \tag{27}$$

for all $t = 0, 1, 2, \ldots$. As in Calvo (1983), only a randomly and independently chosen fraction $1-\nu$ of the firms in the retail sector are allowed to set their prices optimally, whereas the remaining fraction ν adjust their prices by charging the previous period's price times the steady-state inflation. Hence, a retail firm j, which can choose its price in period t, chooses the price $\hat{P}_{it}(j)$ to maximize

$$E_t \sum_{s=0}^{\infty} (\beta\nu)^j \beta_{t,t+s} \left[\left(\frac{\hat{P}_{j,t}(i)}{P_{j,t+s}}\right)^{-\epsilon} Y_{jt+s} \left(\frac{\hat{P}_{j,t}(i)}{P_{j,t+s}} - mc_{j,t+s}\right)\right], \tag{28}$$

where $\beta_{t,t+s}$ is the stochastic discount factor used by the firms and mc_{it} stands for the real marginal costs. The first-order condition for this problem is

$$\hat{P}_{j,t}(j) = \frac{\epsilon}{(\epsilon-1)} \frac{\sum_{s=0}^{\infty} (\nu\beta)^j E_t(\Lambda_{j,t+s} P^{\gamma}_{j,t+s} Y_{j,t+s} mc_{j,t+s})}{\sum_{s=0}^{\infty} (\nu\beta)^j E_t(\Lambda_{j,t+s} P^{\gamma-1}_{j,t+s} Y_{j,t+s})}. \tag{29}$$

2.4. The central bank

The central bank conducts monetary policy according to a modified Taylor (1993) rule:

$$\begin{aligned}\ln\left(R_t/\bar{R}\right) = \quad & \rho_r \ln(R_{t-1}/\bar{R}) + \rho_y \left(\delta \ln(Y_t/\bar{Y}) + (1-\delta)\ln(Y_t^*/\bar{Y}^*)\right), \\ & +\rho_\pi \left(\delta \ln(\pi_{H,t}/\bar{\pi}_H) + (1-\delta)\ln(\pi_{F,t}^*/\bar{\pi}_F^*)\right) + mp_{r_t}\end{aligned} \tag{30}$$

where $\bar{R}$, $\bar{Y}$ and $\bar{\pi}_H, \bar{\pi}_F^*$ are the steady-state values of the gross nominal interest rate, output and gross inflation rate for domestically and foreign-produced goods, and $mp_{r_t} \overset{i.i.d.}{\sim} N(0, \sigma_{r_t}^2)$ is a shock to monetary policy. The coefficient of the degree of interest rate smoothing ρ_r and the reaction coefficients to inflation and output, ρ_π and ρ_y, are positive. The parameter δ denotes the relative steady-state size of the home country vice-versa the foreign country.

2.5. Trade

The real value of net exports is defined using the weighted difference between home production and tradable consumption $NX_t \equiv \frac{P_{H,t}Y_{H,t} - P_{Tt,t}C_{Tt,t}}{P_t}$. Using this definition, we specify total nominal bond holdings B_t according to

$$\frac{B_t}{P_t} = \frac{R_{t-1}B_{t-1}}{P_t} + NX_t. \tag{31}$$

The net change of real bond holding reflects the current account $CA_t \equiv \frac{B_t - B_{t-1}}{P_t}$.

Given two sectors in each economy, it is convenient to define a set of relative prices. The relative price of non-tradables to tradables is defined as $X_t \equiv P_{N,t}/P_{T,t}$ and the terms of trade as $\top \equiv \mathrm{P_{F,t}/P_{H,t}}$. Using these definitions and their foreign counterparts gives us the expression of the real exchange rate in terms of the relative price of non-tradables to tradables and the terms of trade

$$Q_t = \left[\frac{\alpha \top^{1-\gamma} + (1-\alpha)}{\alpha + (1-\alpha)\top_t^{1-\gamma}}\right]^{\frac{1}{1-\gamma}} \left(\frac{X_t^*}{X_t}\right)^{1-\iota}. \tag{32}$$

2.6. Domestic equilibrium conditions

In equilibrium, the value of an open vacancy is zero in both sectors. Making use of the vacancy posting condition (17), combined with Equations (18) and (24), yields the job creation condition

$$\frac{c_j}{q_j(\theta_{j,t})} = (1-\eta)E_t\beta_{t,t+1}\left[mc_{j,t+1}A_{j,t+1}(a_{j,t+1}^N - \mathring{a}_{j,t+1}) - T_j\right]. \tag{33}$$

Equation (33) states that the expected hiring cost that a firm has to pay must be equal to the expected gain from a filled job. Jobs are destroyed by the firm when the realization of the worker's productivity is below the reservation productivity. The reservation productivity is defined as the value of a_{jt}, which makes the firm's surplus received from a job equal to zero,

$$J_{jt}(\mathring{a}_{j,t}) + T_j = 0. \tag{34}$$

The job destruction condition is derived using Equations (19), (23) and (34) and is given by

$$\begin{array}{cc} mc_{j,t}A_{j,t}\mathring{a}_{j,t} - b_j - \frac{\eta}{(1-\eta)}c\theta_t + (1-\zeta_{jt})T_j & = 0 \ . \\ +E_t\beta_{t,t+1}(1-\rho_j^x)mc_{j,t+1}A_{j,t+1}\int_{\mathring{a}_{j,t+1}}^{\infty}(a_{j,t+1}-\mathring{a}_{j,t+1})dF(a_{j,t+1}) & \end{array} \tag{35}$$

with $c_j\theta_{j,t}$ representing the average hiring costs of all firms in either of the two sectors of the economy.

As in Zanetti (2011), the equilibrium average real wage is a weighted average of continuing workers with weight $\omega^C_{j,t} = (1-\rho_{j,t})\frac{n_{j,t-1}}{n_{j,t}}$ while that for new workers is $1-\omega^C_{jt}$. Therefore, the average real wage is

$$w_{j,t} = \eta\left[mc_{j,t}A_{j,t}\overline{a}_{j,t} + c\theta_t + (\omega^c_{j,t} - \zeta_{j,t})T_j\right] + (1-\eta_j)b, \tag{36}$$

where $\overline{a}_{j,t} = \omega^C_{j,t}H(\mathring{a}_{j,t}) + (1-\omega^C_{j,t})a^N_{j,t}$ is the average idiosyncratic productivity across jobs and $H(\mathring{a}_{j,t}) = E(a_{,j,t}|a_{j,t} > \mathring{a}_{j,t})$ represents the average productivity for continuing workers. The aggregate output, net of vacancy costs, amounts to

$$y_{j,t} = n_{j,t}A_{j,t}\overline{a}_{j,t} - c_{j,t}v_{j,t}. \tag{37}$$

Both home and foreign non-tradable consumption must equal demand

$$Y_{N,t} = C_{N,t}\ Y^*_{N,t} = C^*_{N,t},$$

as must home tradable production

$$Y_{H,t} = C_{H,t} + C^*_{H,t},$$

with $C^*_{H,t}$ as the demand for home tradable goods from abroad. Combining this relation with Equation (31) reveals that the foreign trade balance in units of home consumption $Q_tNX^*_t$ must equal the negative home trade balance NX_t.

Now we make use of the market clearing condition for home production and include the demand functions for home-produced tradables, the definition of the real exchange rate and the definition of the terms of trade and the relative price of non-tradables to tradables, which yields

$$Y_{H,t} = \alpha\left[\alpha + (1-\alpha)\top_t^{1-\gamma}\right]^{\frac{\gamma}{1-\gamma}} C_{T,t} + (1-\alpha)\left[\alpha\top_t^{1-\gamma} + (1-\alpha)\right]^{\frac{\gamma}{1-\gamma}} C^*_{T,t}. \tag{38}$$

For domestic and foreign non-tradables we get

$$Y_{N,t} = \frac{1-\iota}{\iota}(X_t)^{-1}C_{T,t}\ Y^*_{N,t} = \frac{1-\iota_F}{\iota_F}(X^*_t)^{-1}C^*_{T,t}.$$

Given that bond markets clear, we are able to get an expression for net exports in terms of non-tradable to tradable prices and the terms of trade

$$NX_t = (X_t)^{\iota-1}\left\{\left[\alpha + (1-\alpha)\top_{\mathrm{t}}^{1-\gamma}\right]^{\frac{1}{1-\gamma}} Y_{H,t} - C_{T,t}\right\}$$

and

$$-\frac{NX_t}{Q_t} = (X_t)^{\iota-1}\left\{\left[\alpha + (1-\alpha)\top_{\mathrm{t}}^{1-\gamma}\right]^{\frac{1}{1-\gamma}} Y_{H,t} - C_{T,t}\right\}.$$

Furthermore, the current account can be expressed as

$$CA_t = (R_{t-1} - 1)\frac{B_{t-1}}{P_t} + NX_t.$$

Finally, we can express tradable consumption in terms of aggregate consumption for the home and the foreign country

$$C_{T,t} = \iota\,(X_t)^{1-\iota}\,C_t\;C^*_{T,t} = \iota\,(X^*_t)^{1-\iota}\,C^*_t.$$

In the steady-state equilibrium, the household's bonds and money holdings are $B_t = B_{t+1} = 0$ and $\varrho_t = M_t - M_{t-1}$, which ensures that any seigniorage revenue is rebated to the households. Furthermore, international financial markets must clear, which implies that $B_t + B^*_t = 0$, where B^*_t represents the nominal bond holdings of domestic assets by foreign households.

3. Calibration

Household preferences are characterized by six parameters: the steady-state discount factor, the two partial elasticities for tradables and non-tradables, the elasticities of substitution between home and foreign-produced tradables, the home bias and the elasticities of substitution for varieties of a good. The periods of the model are calibrated to quarters and we assume both countries and both sectors to be symmetrical. Parameters, therefore, are the same if not indicated otherwise. We set the steady-state discount factor to $\beta = .995$ which is in line with the most recent DSGE models of the Eurozone (Poutineau and Vermandel, 2015), and implies an annual steady-state interest rate of 2 percent. For relative risk aversion we choose the standard value of $\sigma = 2$ (Benchimol and Fourcans, 2012) while Smets and Wouters (2003) suggest a smaller value of 1 and Rabanal and Rubio-Ramirez (2005) estimate a posterior mean that implies a significantly higher risk aversion[8] of above 9.

In the literature we find a variety of definitions distinguishing tradables from non-tradables. We follow Schmillen (2013) who extend a study by Jensen and Kletzer (2012) for the service sectors to assign tradability to NACE sectors.

[8] We tested those values in a sensitivity analysis but the impact on current account imbalances and foreign debt was neglectable.

Given this definition, the size of the tradable sector for France is slightly higher than 53 percent of GDP; for Italy the share is slightly higher than 57 percent and Germany has the highest tradable share at 62 percent. Southern EMU countries, however, have much lower tradable shares. We set the tradable share to 55 percent, which in 2012 was the average for EMU countries. We follow Obstfeld and Rogoff (2007) in setting the preference share parameter to $\alpha = 0.7$ and the elasticity of substitution between home and foreign tradables to $\gamma = 2.0$. The first value reflects the fact that Europeans and Americans attach a consumption weight of 70 percent to their own domestic products. The elasticity of substitution between home and foreign tradables is set according to Obstfeld and Rogoff (1995)[9].

We calibrate the labor market of the model to reproduce the structural characteristics of a typical EMU country. The unemployment rate is set to $u = 9.5$ percent, which is the long-term average among EMU countries. According to Hobijn and Sahin (2007), the quarterly separation rates are 6 percent for Spain and between 3 and 4 percent for France and Germany.[10] Given that the data reflects the period of the Great Moderation and that separations seem to have increased during the crisis, we set the total separation rate to $\rho = 0.05$, which is in the upper range of estimates. Unfortunately, the data does not contain information on the share of the endogenous and exogenous separation in the total separation rate, which, therefore, has to be calibrated using the job creation and job destruction function. The reservation productivity threshold of $\mathring{a} = 1.8$ is calculated at the steady-state intersection of the job destruction and job creation curve. We follow den Haan, Wouter J., Ramey, and Watson (2000) in assuming the idiosyncratic productivity to be log-normally distributed. As Germany is the biggest country in the Eurozone, we mimic the wage distribution of this country, which we have calculated using SOEP data. The mean of $F(.)$, therefore, is calibrated at $\mu_{ln} = 2.54$ and the value of its standard deviation equal to $\sigma_{ln} = 0.48$. We, furthermore, assume that the productivity of new matches is always in the $0.95th$ percentile of $F(.)$ and therefore always above the threshold productivity $a^n > \mathring{a}$, which implies that new matches never separate. Matching efficiency differs to a great extent in the Eurozone. Countries like France, Spain and Italy had a high matching efficiency in the past where estimates range between $\chi = 0.6$ and $\chi = 0.8$ (Ibourk, 2004; Destefanis and Fonseca, 2007; Ahamdanech-Zarco, Bishop, Grodner, and Liu, 2009). Germany is perceived to have a low efficiency, calibrated between $\chi = 0.2$ and $\chi = 0.3$ (Jung and Kuhn, 2014; Krause and Uhlig, 2012). Recently, efficiency has tended to increase in Germany (Fahr and Sunde, 2009; Hillmann, 2009) but shrunk in the other countries mentioned by Arpaia, Kiss, and Turrini (2014). [11] We, therefore,

[9] Obstfeld and Rogoff (2000) and Obstfeld and Rogoff (2007) discuss the issue of an estimation bias using aggregate trade data which results in a lower than unity elasticity of substitution .

[10] The value for Germany is extremely close to the $\rho = 0.03$ separation rate calculated by Kohlbrecher et al. (2013) using German administrative data.

[11] The matching efficiency in the Eurozone is perceived to be lower than that of the United States Jung and Kuhn (2014). Lubik (2013) estimated the beveridge curve for the US using

follow Lubik and Krause (2014) and set the matching efficiency[12] to $\chi = 0.5$, which is in line with the long-term unemployment level of the Eurozone.

The elasticity of a match w.r.t. the unemployed is calibrated to $\xi = .7$, which reflects estimates by Burda and Wyplosz (1994) for Germany and France, Kohlbrecher, Merkl, and Nordmeier (2013) for Germany and Broersma (1997) for the Netherlands and is in line with the studies surveyed in Petrongolo and Pissarides (2001). As is standard in the literature, the Nash bargaining coefficient used in the wage-setting equation is set to $\eta = 0.5$, such that workers and firms have the same bargaining power[13]. The vacancy posting costs in the baseline scenario $c = 5.2$ and the unemployment benefits b are inferred from the steady-state job destruction and job creation conditions. The parameter measuring leisure is calibrated to $h = 0.3$, so that the income from not working (b and h) is worth 77 percent of w. Firing costs T are set to 67 percent, which is calculated as the EMU average using the World Development Indicators (WDI) database, while the replacement rate is 60 percent of the mean wage. This is in line with the study by van Vliet, Been, Caminada, and Goudswaard (2012) which calculates a replacement rate of between 50 and 60 percent for most EU-countries. The core countries of the Eurozone have values above 60 percent while Malta and members of the Eastern enlargement round have lower values (30 to 40 percent).

As is common in the literature, the parameter measuring the market power of retailer is set to $\varepsilon = 11$. This implies a mark-up over marginal costs of 10 percent and reflects empirical findings. The Calvo parameter that governs the frequency of price adjustments is, in accordance with Taylor and Woodford (1999), set to $\nu = 0.75$ such that the average binding of prices is 4 quarters. As is common, we normalize steady-state inflation to unity. The Taylor rule is calibrated following Taylor and Woodford (1999), and implies a monetary policy response to inflation equal to $\rho_\pi = 1.5$, a response to a change in output of $\rho_y = .5$ and a degree of interest rate smoothing of $\rho_r = .32$.

Finally, we specify the shock processes. In line with most of the literature, we calibrate the productivity shock such that the baseline model replicates the standard deviation of output in the Eurozone, which on average is 1.64. The standard deviation of the shock in either of the two sectors consequently amounts

data from 2000 to 2008. The point estimate for the matching efficiency is $m = 0.8$ which is significantly lower than the matching efficiency we set for the Eurozone. Most studies like Jung and Kuhn calibrate the US matching efficiency lower between 0.5 and 0.6.

[12] We also run the model with a significant lower matching efficiency of 0.23 following Jung and Kuhn (2014). The volatility of total vacancies and unemployment is to low in this specification, so that we returned to the standard specification. We could improve the buisness cylce statistics by setting the bargaining power according to Hagedorn and Manovskii (2008). If we, however, run the model with the standard matching efficiency and the Hagedon-Manovskii specification, the business cycle statistics better matched the data (Business cycle properties for this calibration are available in an online supplement)). We did not use this specification as it was inconsistent with the long-term unemployment rate of EU-countries and the distribution of wages.

[13] A low bargaining power of workers specification following Hagedorn and Manovskii (2008) can be found in table (Business cycle properties for this calibration are available in an online supplement).

to $\sigma_a = 0.0087$, while the shock persistence parameter is $\rho_a = 0.94$. From Crespo-Cuaresma and Fernandez-Amador (2013) it follows that the standard deviation of demand shocks should be roughly similar to that of supply shocks from 1990 onward, while supply shocks had twice the standard deviation of demand shocks in the 1960s. We set the standard deviation of the time preference shock to $\sigma_a = 0.013$ and the shock persistence parameter to $\rho_a = 0.94$ reflecting the importance of demand shocks[14] for the Eurozone (Wyplosz, 2013). We follow the findings of Uhlig (2005) that monetary policy shocks contribute to less than 10 percent of the volatility of output in setting the standard deviation of the monetary policy shock to $\sigma_a = 0.0016$ with a persistence of $\rho_a = 0.25$. The matching efficiency shocks are assumed to have a standard deviation of $\sigma_a = 0.0016$ and a persistence of $\rho_a = 0.25$. These values are in-line with those of estimated DSGE models of the Eurozone (Smets and Wouters, 2003; Ratto, Roeger, and Veld, 2009; Zhang, 2013).

4. Results

In this section we present the results of our simulation exercise. In the first sub-section, we show the impact of three reform measures - a reduction in vacancy posting costs, more efficient placement, and a lower replacement rate - on the four sectors of our two-economy model. In the second sub-section we will discuss the impulse response functions (IRF) that show the adjustment of the economy after a transitory shock and, finally, we will assess the robustness of our results.

4.1. Steady-state analysis

Our model is calibrated to reflect the structure of a typical EMU member state (see section 3). In the benchmark scenario, both countries are symmetrical. In our three policy scenarios we have changed the labor market framework to reproduce the impact of labor market reforms. The steady-state values of the four scenarios are presented in Table 1.

In the first policy scenario, the replacement rate for unemployed workers is reduced by one percentage point. Krause and Uhlig (2012), among others, consider the reduction of the replacement rate and the regime shift from an earnings-dependent to an earnings-independent system as crucial in explaining the large drop in unemployment in Germany. In the second scenario, we reduce vacancy posting costs. As mentioned earlier, a reduction in regulatory requirements for the posting of workers industry reduces the vacancy posting costs for firms, as there is an additional option for hiring workers with specific skills. In our third policy scenario, we follow Fahr and Sunde (2009), who analyze the increase in matching efficiency related to labor market reforms. The UK,

[14] We also account for asymmetric demand shock but, in difference to Wyplosz, assume the same standard deviation of shocks.

the Scandinavian countries, the Netherlands and Germany introduced one-stop jobcentres to make it easier for the unemployed and the employers to connect.

The calibration of the model to the characteristics of a typical EMU member state results in a threshold productivity of 2.71. As there are only a small number of models with a search and matching framework and endogenous separations are available, we have to compare this figure with a model calibrated for a non-EMU country. Our threshold productivity is slightly higher than the corresponding figures for the UK (Zanetti, 2011), an EU country but not a participant in the EMU. In the UK, unemployment benefits are lower compared to continental European countries. As with increasing benefits the threshold productivity increases, we can explain these differences.

In our first policy scenario, we assume that the replacement rate of the domestic country is reduced by 1 percentage point compared to the benchmark rate. Through this reform measure, the domestic country experiences lower wages[15], a decreasing threshold productivity[16] and a fall in endogenous separations. A more stable steady-state workforce, generally, decreases the necessity for firms to post vacancies[17]. The value of a vacancy increases, which results in an opposite effect, i.e. of increasing the probability of firms to open new positions. In our model, the latter effect dominates, thereby, increasing the number of vacancies. Both a rising number of vacancies and a falling unemployment rate increases labor market tightness sharply.

In the second policy scenario, we reduce the vacancy posting costs by roughly two percent. In Table 1 we see a rising labor market tightness, firms open more positions as costs shrink. As the reduction in labor market tightness is stronger than the reduction of posting costs, it follows from equation (36) that wages increase in both sectors increasing the threshold productivity and endogenous separations. Given the productivity distribution for Germany that we calculated using the income distribution, this increase has only minor effects on total job separations. The most important impact of a reduction in vacancy posting costs is on the job creation condition (equation 33) where lower costs intensify the number of positions opened by the firms. Consequently, vacancies increase and the unemployment rate falls.

In our third policy scenario we raise the matching efficiency parameter from 0.5 to 0.51, or by roughly two percent. The number of matches given, the number of vacancies and the number of unemployed workers increase. This has two implications for a firm.Firstly, as it becomes more likely that a position is filled, the costs of a match fall. The fall in the costs of a match, given the job destruction condition, increases separations, as it is less costly for a firm to replace workers. The threshold productivity and the number of transitions to unemployment, therefore, increase. The real wage also rises, since the average productivity increases with the rise in the threshold productivity. Secondly, an

[15]This follows directly from the wage equation (36).

[16]A decrease in the threshold productivity follows from the job destruction condition (35).

[17]This results from the job creation (33)

increase in matching efficiency also raises the probability of finding an appropriate worker in a given time span. With the increase in the speed of the matching process, unemployment declines. The magnitude of both effects depends on the calibration of the model. In our case, we observe a reduction in unemployment. The impact of an increase in matching speed outweighs the increase in job separations. Finally, firms can increase production as more workers are employed and the employed workers have a higher average productivity.

For the foreign country, labor market reforms affect the sectoral division of production. In all our scenarios, output in the tradable goods sector increases. By shifting consumption towards the tradable goods sector the households in the foreign country can increase utility, given the substitutability of non-tradable and tradable goods. As consumption shifts to tradables, production in the foreign country follows the change in consumption pattern.

Table 1 on page 36 about here

4.2. Shock responses

In this section, we discuss the impulse responses to a positive domestic technology shock, a negative foreign technology shock, a monetary policy shock and a time-preference shock affecting households living in the domestic economy. With the exception of the monetary policy shock, all shocks increase the debt of the foreign country.[18]

4.2.1. Domestic productivity shock

In Figures 1, 2 and (3), we have visualized the response of the model to a positive technology shock on domestic production of one standard deviation. On impact, output in both sectors increases while inflation declines. Owing to price rigidities, not all firms are able to adjust prices in the first period. The increased productivity raises the value of a match, the threshold productivity declines and workers who would otherwise have been fired because of below steady-state threshold productivity now remain employed. As separations diminish, an increase or reduction in vacancies becomes dependent on the calibration of the model. In our case, we observe the conventional increase in vacancies and a drop in the unemployment rate amplifying labor market tightness. Diminishing separations are exactly the reason why both the average idiosyncratic productivity of workers and transitions from employment in the tradables sector to unemployment decline. As prices in the non-tradable sector are more flexible regarding domestic shocks, the price relation of non-tradable to tradable goods also declines. Domestic households shift consumption towards non-tradable

[18] Please note that due to endogenous job destruction, the adjustment of the economy after a positive and negative shock is not symmetric (see also Pissarides 2000, chapter 2).

goods. Foreign households rather experience a drop in the prices of tradable goods produced in the domestic country and shift consumption toward those goods. As it is known that the shock is transitory, that terms of trade will improve in the future and that exchange rates are irrevocably fixed in a currency union, it is beneficial for households in the foreign country to go into debt.

In this model, wages are bargained in the second stage of a two-stage process. In the first stage, workers and firms decide whether to match or not, in the second stage the individual wages are negotiated according to the idiosyncratic productivity. The impact on average wages, therefore, is not clear. As total factor productivity increases, there is a positive stimulus on the average wage. The marginal costs decline, serving as a negative stimulus, as does a drop in the average productivity. In the first period after the shock, wages decline as job separations are reduced and average idiosyncratic productivity falls sharply, overcompensating for the increase in total factor productivity. In the second period, new workers hired in the first period begin their employment, raising average idiosyncratic productivity and average wages (Figure 3).[19]

In both sectors, vacancies increase and the number of workers searching for employment drops, although this drop is more pronounced in the non-tradable sector. Job creation is stronger in the tradables sector and we see a shift from non-tradable to tradable employment in the first periods. With a declining demand among foreign households for non-tradables, this pattern is reversed in later periods.

Figure 3 on page 40 about here

All our four scenarios follow the pattern just sketched. In the first indicated by a broken line, we have reduced unemployment benefits by one percentage point as compared to the benchmark scenario, indicated by a continuous line. The impact of an increase in total factor productivity is weaker when compared to the benchmark case (Figures 1 and 2). This effect results from a larger drop in endogenous job destruction. As we see in Table 1, the steady-state of this scenario is characterized by a low threshold productivity, implying fewer endogenous job-separations as compared to other scenarios. Given the distribution of the idiosyncratic productivity of workers, a further drop in the threshold results in a much weaker decline in endogenous job-separations.

Furthermore, labor market tightness is stronger in the steady-state, which reduces the probability of filling a position in a given span of time. Firms, nevertheless, create more vacancies as they are not able to adjust employment fully by simply keeping workers. Both these factors increases labor market tightness further, which has a dampening effect on job creation and employment. To increase production in the tradable sector, therefore, the number of workers

[19]Please note that we assumed that the productivity of new workers is strongly above average in the first period to avoid hiring and immediate separations.

employed in the non-tradable sector has to be reduced more sharply. In sum, employment is lower in both sectors as compared to the benchmark scenario, as goods production also reduces the impact on inflation. Foreign households tend to benefit less from net-exports and the resulting increase in foreign debt.

Our second policy scenario, indicated by a dotted line (Figures 1 and 2), shows a reduction in vacancy posting costs. As shown in the steady-state section, this makes hiring workers less costly and increases the threshold productivity. Compared to the benchmark scenario, more workers remain employed than before, as their idiosyncratic productivity is above the threshold level. This holds true on the assumption of a normal distribution of the idiosyncratic productivity of workers. The more workers the firm holds, the fewer vacancies it posts. This effect is so strong that it overcompensates for an increase in vacancies following a reduction in costs.[20]

Vacancy posting costs, furthermore, have a stronger impact on the number of vacancies compared to the benchmark case. In sum, we see a tiny improvement in the terms of trade, an increase in net exports and an increase in foreign debt compared to the benchmark case. The impact, however, is very small.

Figure 1 on page 38 and Figure 2 on page 39 about here

A third policy scenario, where we have increased the matching efficiency by two percent, is indicated by a dotted / broken line (Figures 1 and 2). Here we record a stronger increase in the tradable goods production as compared to the benchmark case. Gains in production are again caused by a stronger rise in employment, a stronger drop in unemployment, but also a weaker increase in vacancies. The reason for the increase in employment is a better matching of workers, which on the one hand reduces the time workers spend searching for a job and, therefore, unemployment, while on the other, the time span of an open vacancy is lessened, reducing the number of open vacancies as compared to the benchmark case. In sum, more workers produce a higher output, as compared to the benchmark. Again, the increase in output necessitates a stronger drop in prices which, in turn, raises net exports and foreign debt.

4.2.2. Foreign productivity shock

In the previous section, a positive technology shock in the domestic country was the reason for an increase in the foreign countries foreign debt. A negative technology shock in the foreign country should also increase foreign debt for similar reasons. Unlike the case in the domestic country, we here analyze a

[20]It can be easily shown that the impact of vacancy posting costs on a change in vacancies depends on the distribution of idiosyncratic productivity by comparing the standard case with our sensitivity case. In our sensitivity scenarios, where the standard deviation of the productivity distribution is smaller, the increase in vacancies due to cost reduction overcompensates the reduction in vacancies due to less separations.

shock that affects the tradable goods sector only. In the benchmark scenario, the negative technology shock improves the terms of trade in the domestic economy (Figure 4). As in the scenario with a positive technology shock, net exports increase and, consequently, the foreign country experiences a rise in debt. Households in both countries shift consumption from foreign tradables, where prices tend to rise, to tradables from the domestic economy. In sum, the prices of tradables rise, which is why households shift from tradable to non-tradable consumption. The impact of the shock on tradable goods production in the domestic economy is ambiguous. Demand by households for tradables shrinks as they shift from tradable to non-tradable goods but also increases as they move from foreign tradables to domestically produced ones. Additionally, households in the foreign country increase their demand for tradables produced in the domestic economy but reduce their overall demand for tradables. It is, therefore, likely that the demand for domestically produced tradables will increase, inducing a rise in production. If production increases, the demand for labor grows and the threshold productivity declines, reducing the number of endogenous job separations. In a similar fashion to the previous shock, non-tradable output is affected by the demand for tradable goods. If the demand by foreign households for domestic tradable goods is strong and foreign tradables play a minor role in the overall tradable goods consumption of domestic households, then it is likely that non-tradable production will decline. If domestic households substitute tradable goods for non-tradables and foreign tradable demand is weak, we observe an adverse effect. Given the calibration of our model, we observe a reduction in non-tradable production in the first periods and an increase thereafter, indicating that the increase in demand for domestic tradable goods by the foreign country is sizeable.

Labor market reforms, again, affect the pattern of adjustment to a macroeconomic shock. The impact of the shock on employment is smaller if the replacement rate is lower: a reduction in job separations is less pronounced reducing the impact on unemployment. If firms wish to raise employment, they have to increase the posting of vacancies by larger amounts than in the benchmark case. Consequently, the increase in output in general is weaker, reducing the impact on prices, and the shift in employment from the non-tradable to the tradable sector is weaker. This results in a stronger rise in the prices of tradable goods than in the benchmark case and a smaller increase in net exports and foreign debt.

Figure 4 on page 42 about here

Again, as in the scenarios with a technology shock affecting the domestic country, an increase in matching efficiency and a reduction in vacancy posting costs have a unidirectional impact on vacancies and unemployment. The reasons for the lesser impact of a shock on vacancies in these two scenarios as compared to the benchmark case are grounded in the steady-state threshold productivity levels.

A reduction in vacancy posting costs and an increase in matching efficiency both reduce the steady-state threshold productivity level. If there is a shock to total factor productivity, the threshold level declines and job separations are reduced. As the threshold productivity is lower in the benchmark case, fewer workers are affected by a productivity shock that reduces threshold productivity as compared to the other two scenarios. This effect is strong enough to overcompensates for the increase in vacancies in the vacancy posting cost reduction scenario. In the matching efficiency scenario, conversely, the impact is intensified as the speed of the matching process reduces the duration that is needed to fill a vacancy which then reduces the number of vacancies further.

For the foreign country, a flexible adjustment in the tradable sector of the domestic economy enhances the benefits of an increase in debt. We have seen that a reduction in the replacement rate weakens the economy's ability to reacting to productivity shocks. The adjustment of the foreign economy, therefore, has to be keener and the increase in foreign debt of the foreign country will be consequently lower. In the scenarios of vacancy cost reduction and of an increase in matching efficiency, the economy is more flexible in its ability to adjust employment on impact. The tradable sector in the foreign country does not need to adjust that much, increasing its net exports and its foreign debt.

4.2.3. Time preference and monetary policy shocks

The time preference shock affects the stochastic discount factor in our model. Households tend to discount the loss in utility of shifting consumption to future periods by a smaller amount. We observe a reduction in consumption which brings down prices in both sectors of the domestic economy. For foreign households, domestic tradables become less expensive. Households in the foreign country shift consumption from foreign to domestically produced tradables and from the non-tradable to the tradable sector. In the domestic economy, we see a shift in production from the non-tradable to the tradable goods sector while in the foreign country tradable production declines. With rising net-exports, the foreign debt of the foreign country also increases (Figure 4).

The increase in foreign debt of the foreign country depends on the flexibility of the domestic country in shifting production from the non-tradable to the tradable goods sector. In the scenario with an increase in matching efficiency, the time taken for a vacancy to be filled is shorter and production can adjust more quickly. Foreign debt, therefore, increases by more than in the benchmark case. A fall in vacancy posting costs increases job separations and also helps to adjust production more quickly, but the impact is smaller than in the matching efficiency scenario. In the reduction of the replacement rate scenario the impact of the shock on unemployment is lower. Fewer workers switch from one sector to the other and production is more stable. The foreign debt of the foreign country reacts less strongly.

A positive monetary policy shock has no impact on debt in the benchmark case. The transmission of monetary policy is identical in both countries. On impact, inflation diminishes and consumption increases. As prices adjust, both sectors have to reduce production and employment. In the scenario with a reduction in unemployment benefits, employment is less volatile in the domestic economy as compared to that of the foreign country. Prices in the foreign economy react less strongly than those of the domestic economy. Terms of trade in the domestic country improve and foreign households shift consumptions toward tradables and domestic tradables. The foreign debt of the foreign country rises (Figure 4). In the scenario with a fall in vacancy posting costs and an increase in matching efficiency, the domestic country reacts more strongly to the monetary policy shock and reduces output and employment more strongly than in the benchmark scenario. Domestic prices, therefore, are higher than foreign prices, the terms of trade worsen and we see a decline in foreign debt. The overall impact of a monetary policy shock on debt, however, is small compared to productivity and time-preference shocks.

4.2.4. Business cycle properties

In this section, we analyze the impact of labor market reforms on the business cycle dynamics of our model. We begin by discussing the plausibility of business cycles generated by the benchmark calibration of the model and compare the results with previous studies using similar models. In Table 2 we compare cross-correlations found in the data (Column 1) with the benchmark case (Column 2) and the three labor reform scenarios (Column 3 - 5).

Table 2 on page 37 about here

The co-movement of inflation and de-trended output is positive in countries being members of the Eurzone today (Andrle, Bruha, and Solmaz, 2013; Kiley, 1996). This is consistent with the findings of den Haan, Wouter J. and Sumner (2004) if we account for the fact that the price level appears to be counter-cyclical if inflation follows output positively and with a lag (Ball and Mankiw, 1994; Chadha and Prasad, 1994). This indicates that demand shocks play an important role in determining business cycles in the Eurozone. The benchmark case can mimic the positive correlation of HP-filtered output and inflation. The correlation, however, is less strong in our model.

In most post-war studies of the US, wages are slightly pro-cyclical and this pro-cyclical behavior increases over time (Abraham and Haltiwanger, 1995). For Germany as the biggest economy in the Eurozone evidence is mixed. More recent studies like Marczak and Beissinger (2013) and such as Messina, Strozzi, and Turunen (2009) find a procyclical pattern, while Lucke (1997) and P J Pérez (2001) using data up to the 1990s, find an acyclical pattern. The correlation we get from our model of a Eurozone country is surprisingly strong, especially for the tradable-goods sector. Verdugo (2014) also found strong pro-cyclical patterns after controlling for a composition effect during the recent Great Recession. To some extent, we might capture this effect by seperating tradable and non-tradable goods. While our model matches the correlation of output and real wages for non-tradables, it fails to produce the strong correlation found for output and real wages in the tradable goods sectors. However, more empirical research is needed to confirm that there really is a strong pro-cyclical pattern to Eurozone real wages.

The correlation of unemployment and vacancies has to be strongly negative for the US (Shimer, 2005). The correlation of Eurozone unemployment and vacancies seems to have the same sign but is slightly weaker. The model mimics the counter-cyclical relationship between unemployment and vacancies, but fails to produce the strong correlation. This is a typical phenomenon among models with endogenous job destruction, as fluctuations in the separation rate induce a positive relationship between unemployment and vacancies (Shimer, 2005; Zanetti, 2007).

As we have no wage rigidities in our model, real wages fluctuations are driven predominantly by fluctuations in productivity and in the labor force i.e. by migration. Endogenous separations, nevertheless, impose an acyclical behavior on real wages. Workers endogenously separate from firms if the idiosyncratic productivity is below a threshold level. The threshold level declines in a boom and increases with a recession. Given that workers, to some extent, are rewarded according to their individual productivity, the average wage increases in times of recession and is reduced in times of a boom. Whether wages are pro- or acyclical depends, therefore, on the income distribution defining the idiosyncratic productivity of workers. In our model, wages are procyclical, inflation is procyclical and, as a consequence, real wages and inflation have to be positively correlated. This also reflects the pattern of real wages in the tradable, but not in the non-tradable sector. Some nominal wage rigidities might exist that prevent wages from adjusting to shocks. This could create an acyclical pattern of real wages. Radowski and Bonin (2010) find some evidence for this hypothesis in their analysis of the wage-setting behavior of firms in Germany using survey data. According to this study, service sector firms tend to freeze nominal wages more frequently than firms in the manufacturing sector.

If we compare the benchmark standard deviations with the Eurozone figures we find a pattern common to most search and matching models. The volatility of vacancies and unemployment is significantly lower than that seen in the data (Shimer, 2005). The reason for this low volatility, however, is somehow different from in previous models. If we compare standard deviations in the tradable and non-tradable sectors, they virtually match the data. The fluctuation of total unemployed and total vacancies, however, is much too low. The reason for this phenomenon is to be found in the assumption that workers can choose either of the two sectors in which to search for employment. A worker who has recently separated from a firm in the tradable sector is able to search for new employment in the non-tradable sector and vice-versa. If the shocks are not perfectly correlated, the labor market effects of productivity shocks on either one of the two sectors cancel out. If there is a positive productivity shock in the tradable goods sector workers immediately increase searching in this sector. Vacancies in the tradable sector increase but those in the non-tradable good sector, because of an increase in labor market tightness, instantly drop. With a rise in vacancies in one sector and a drop in the other, overall fluctuations are small.[21] There are two ways to cope with this problem: either to introduce the costs of switching occupations or by reducing the volatility of real wages and employment which would then increase the volatility of unemployment and vacancies. Hagedorn and Manovskii (2008) suggest altering the calibration of the Nash bargaining rule determining wages. In the H-M calibration, we can, indeed, replicate a high volatility of vacancies and unemployment. Another way would be to introduce nominal and real wage rigidities. As Krause and Lubik (2007) show, the impact on volatilities cancels out in sticky price models, so we decided not to include sticky wages in our sticky price model.

In the third to fifth columns of Table 2 business cycle properties of the labor market reforms are presented. In general, fluctuations of vacancies and the unemployment rate increases slightly when the replacement ratio decreases and drops, if the matching efficiency increases. Fluctuations of real wages follow a reverse pattern. Vacancy posting costs reduce fluctuations in real wages, at least in the non-tradable goods sector, and increase fluctuations of vacancies and job-searchers in both sectors. The overall impact of reforms on business cycle properties, however, is small.

Business cycle properties look more favorable if we switch to a calibration with a low bargaining power for workers. The real wage depends in this setting to a great extent on unemployment benefits which we assume do not fluctuate. The volatility of real wages, therefore, is lower, while that of total vacancies and unemployment is much higher and in the case of unemployment benefits close to the volatility of the time series. Fluctuations in production are lower and more close to the time series than in the standard calibration. In this calibration, however, fluctuations in tradable goods production are lower than those in the non-tradable goods sector, which does not match the data. Cross correlations have, as in the standard calibration, the right sign. The only exception are real wages in the non-tradable sector which are negatively correlated to inflation, but strongly positively correlated in our standard calibration as well as in the calibration with a low bargaining power for workers. Correlations of real wages and output, as well as the correlation of output and inflation, are more close to the data in this calibration, but the negative correlation between vacancies and the unemployment rate is much too high.

Even though business cyle properties looked more favorable, we did not switch to the calibration with a low bargaining power for workers. The reason for this lies in the fact that steady-state values do not match the data. The proportion of workers looking for a job, given our assumptions on the distribution of income, is too high (31 percent).

[21]As we tried to be parsimonious and through we believe that the qualitative results of the labor market reform measures with regard to the benchmark scenario will not be affected, we did not introduce such costs here.

4.2.5. Sensitivity analysis

The results of our model clearly depend on the distribution of the idiosyncratic productivity shock that we calibrated in Section (3). Calibrating the model to reflect the properties of a typical member country of the EMU results in a low value for endogenous job destruction. The standard deviation of idiosyncratic productivity was 0.48, which is broadly in line with Trigari (2009). In this section, we lower the standard deviation to 0.38, which reduces the steady-state labor market tightness, given a steady-state threshold productivity of 2.73.[22] The threshold productivity is similar to that in the standard benchmark scenario, unemployment benefits are higher (9.1 compared to 8.5), while real wages are lower (12.5 compared to 13.1). Total output 12.3 is also lower as compared to the standard benchmark case of 13.

Reducing the standard deviation in the idiosyncratic productivity in all sectors of both countries raises the productivity threshold from 0.25 to 3. A new value for the equilibrium threshold productivity requires a new full set of calibrations. These new parameter values yield higher steady-state unemployment, lower average real wages, and a lower output. The qualitative results of the previous section, nevertheless, remains the same. In general, the impact of labor market reforms turns out to be weaker, the labor market is tighter and weaker in adjusting. The scenario with a reduction in the replacement rate (broken line) still has the lowest impact on tradable production and consumption after a positive domestic productivity shock. The foreign debt of the foreign country increases less strongly. The scenario with a higher matching efficiency (dotted / broken line) increases the flexibility of production and increases foreign debt most strongly. The impact of the scenario with an increase in vacancy posting costs remains weakly increasing in foreign debt.

Figure 3 on page 40 about here

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5. Conclusion

After the creation of the EMU, current account imbalances increased sharply as expectations regarding growth in the periphery of the union failed to materialize (Blanchard, 2007) and both the core and the periphery of the Euroarea were hit by common, asymmetric, macroeconomic shocks. In the economic literature there is a discussion concerning to what extent structural reforms, and, more explicitly, labor market reforms, contributed to these imbalances. In this paper we have examined the effects of three types of labor market reform measures, namely a fall in the replacement rate, an increase in matching efficiency, and a reduction in vacancy posting costs on the foreign debt of a non-reforming country, reflecting current account imbalances of previous periods. If the reforming

[22]The IRFs for the sensitivity analysis are available in the Figures supplement

country increases its current account surplus because of these reforms, some speak of a beggar-thy-neighbor policy.

The first reform measure, a reduction in the replacement rate, reduces both, steady-state unemployment and endogenous job destruction. This is closely related to a lower impact of shocks on output, prices and, therefore, also on net exports. The increase in foreign debt of a non-reforming country in the presence of asymmetric productivity shocks is weaker when compared to the benchmark case. The increase in matching efficiency, by contrast, corresponds to a higher level of foreign debt among non-reformers, as endogenous job-destruction increases and the length of time of a vacancy being open decreases. This, in turn, amplifies the impact of a shock on employment, production and, therefore, all macroeconomic variables related to changes in prices. A higher matching efficiency, thus, leads to an increase in employment and output in the steady-state, but comes at the cost of higher fluctuations in output and prices, an increase in the impact of a shock on net exports and a stronger impact on the level of foreign debt of the non-reforming country. Finally, the third reform measure, a reduction in the costs of posting a vacancy, enables firms in the reforming country to alter employment at a lower cost and, thus, more strongly. With an increase in vacancies, unemployment is reduced. This, however, contrasts with an increase in job separations. It is less costly for a firm to open vacancies and hire new, more productive workers. As the duration of unemployment is not affected by the reform, we have an ambiguous impact of the reform on unemployment depending on calibration. In our case, we observe a fall in unemployment, an increase in employment and a small increase in the foreign debt of the non-reforming country after an asymmetric productivity shock hit the economy.

In the case of a positive technology shock hitting a reforming country with the characteristics of a typical EMU member, fears about a beggar-thy-neighbor policy which leaves non-reforming countries with a loss of competitiveness and an increase in foreign debt cannot be corroborated by us for the specific bundle of reforms considered here. A reduction in the replacement rate more or less compensates for an increase in matching efficiency and a drop in vacancy posting costs in the case of productivity shocks. These two shocks reduce foreign debt and compensate for a fall in the replacement rate in the case of time-preference and monetary policy shocks. This, however, does not hold when labor market reforms concentrate on single measures or apply reforms unevenly.

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Tables and Graphs

Table 1: Steady state values

Variable	Benchmark	Decrease in replacement ratio	Decrease in the vacancy posting costs	Increase in matching efficiency
		change in percent (unemployment rate in percentage points)		
Output	13.05	0.06	0.06	0.19
Unemployment benefits	8.48	-1.65	0.03	0.11
Labor market tightness	0.73	2.89	2.02	0.18
Unemployment rate	10	-0.2	-0.01	-0.02
		Tradable goods sector		
Output	6,70	0.05	0.05	0.16
Employment	0.46	0.17	0.01	0.01
Vacancies	0.038	1.26	1.83	-0.13
Real wages	13.14	-0.11	0.03	0.12
Threshold productivity	2.74	-14.03	3.74	12.77
Job destruction rate	0.05	-0.9	0.4	1.74
		Non-tradable goods sector		
Output	6.36	0.07	0.07	0.21
Employment	0.44	0.18	0.03	0.06
Vacancies	0.036	1.28	1.84	-0.08
Real wages	13.14	-0.11	0.03	0.12
Threshold productivity	2.74	-14.03	3.74	12.77
Job destruction rate	0.05	-0.9	0.4	1.74
		Foreign economy		
Output tradables	5.27	0.02	0.02	0.07
Output non-tradables	7.79	-0.02	-0.01	-0.05

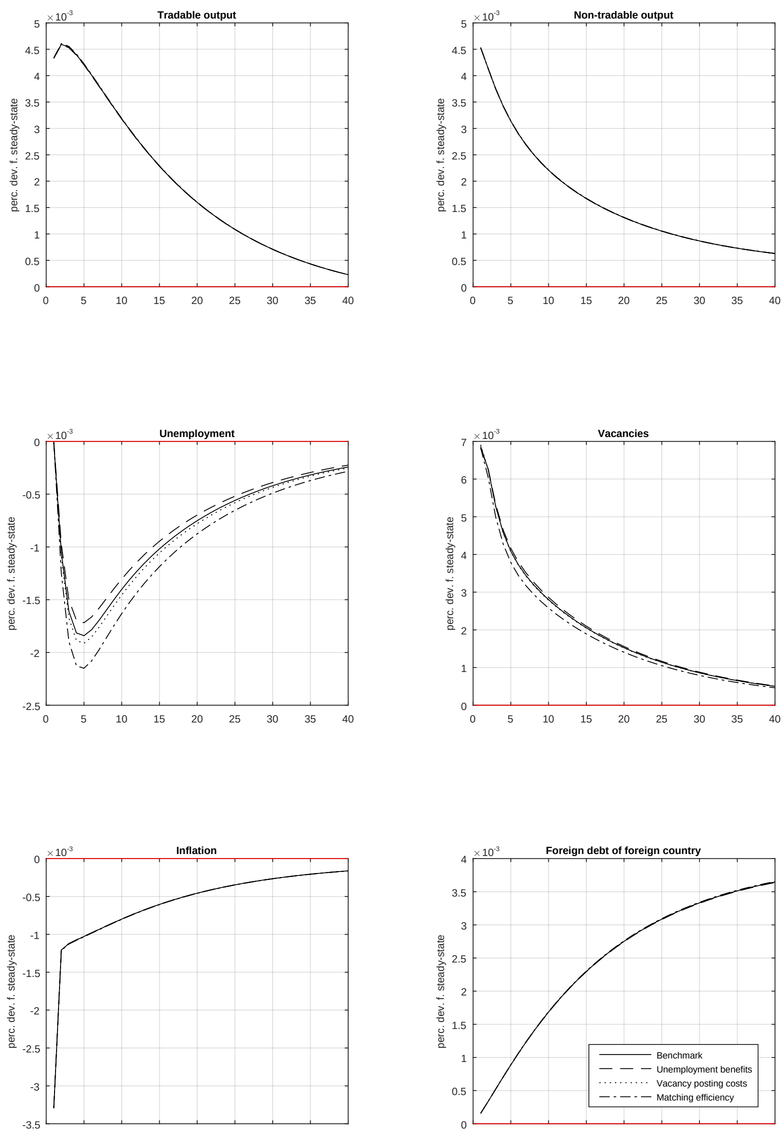
Notes: Entries in this table are computed using the calibration described in section (3)

Table 2: Business cycle properties, all shocks

Variable	Euro Area	Benchmark	Decrease in the replacement ratio	Decrease in vacancy posting costs	Increase in matching efficiency
		Standard deviations			
GDP	0.0164	0.0164	0.0164	0.0165	0.0165
Vacancies	0.1079	0.0485	0.0479	0.0494	0.0515
Unemployment	0.0712	0.0126	0.0123	0.0130	0.0150
Employment		0.0013	0.0013	0.0014	0.0016
Inflation	0.0069	0.0497	0.0497	0.0496	0.0494
		Tradable goods sector			
Production	0.0241	0.0365	0.0365	0.0365	0.0366
Employment	0.0057	0.0276	0.0276	0.0276	0.0277
Vacancies		0.2104	0.2108	0.2107	0.2102
Job searchers		0.1642	0.1640	0.1643	0.1650
Real wage	0.0135	0.0889	0.0884	0.0887	0.0885
Labor market tightness	0.1573	0.0531	0.0535	0.0534	0.0523
		Non-tradable goods sector			
Production	0.0109	0.0319	0.0320	0.0319	0.0319
Employment	0.0072	0.0277	0.0278	0.0277	0.0275
Vacancies		0.1412	0.1425	0.1399	0.1358
Job searcher		0.1834	0.1854	0.1823	0.1770
Real wage	0.0101	0.6656	0.6674	0.6644	0.6604
Labor market tightness	0.1573	0.0531	0.0535	0.0534	0.0523
		Cross correlations			
Output, real wages T	0.8622	0.1666	0.1659	0.1692	0.1761
Output, real wages NT	0.4381	0.0969	0.0951	0.0991	0.1071
Output, Inflation	0.5433	0.0128	0.0111	0.0147	0.0215
Real wages T, Inflation	0.3226	0.9738	0.9735	0.9736	0.9735
Real wages NT, Inflation	-0.4357	0.9777	0.9778	0.9777	0.9775
Unemployment, vacancies	-0.5766	-0.2511	-0.3559	-0.1848	-0.0876

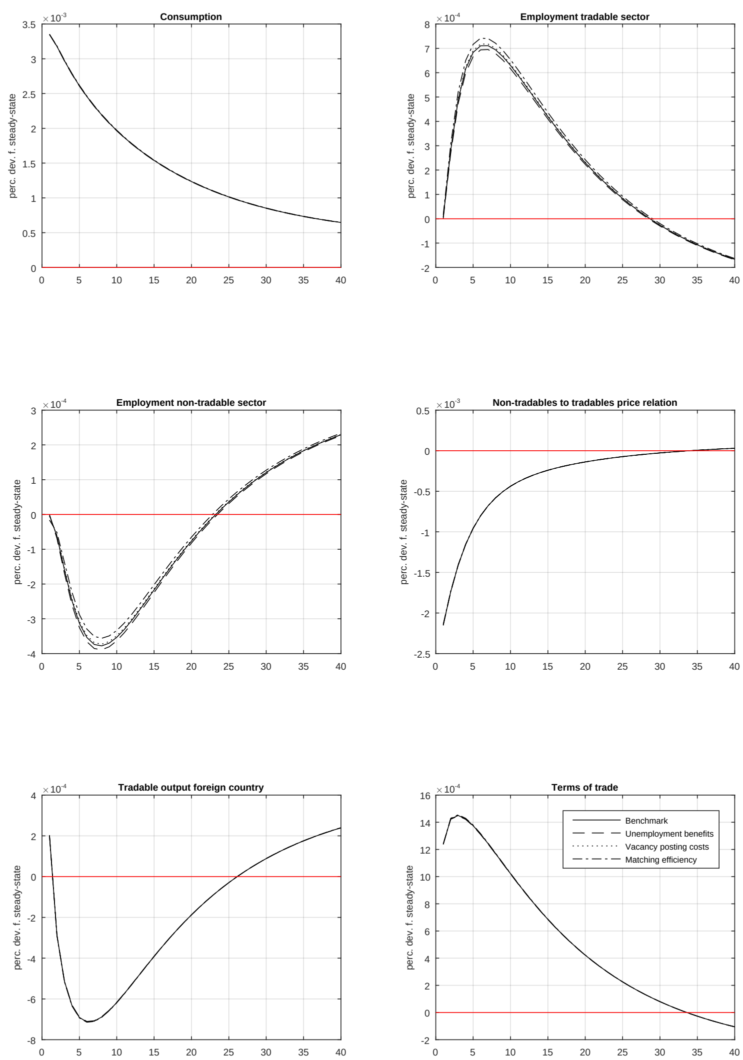
Notes: Observed and simulated business cycle properties for the Eurozone (EA-12). The observed statistics are based on seasonally adjusted quarterly data from 2006:Q1 to 2012:Q2. Variables, except inflation, are transformed into logarithms. All the series are HP filtered (frequency 1600), so that only the cyclical component remains. The simulated business cycle statistics are based on 1000 simulations over 100 quarter horizon and are HP filtered for comparison purposes. Simulated figures are averages across simulations.

Figure 1: Positive domestic technology shock



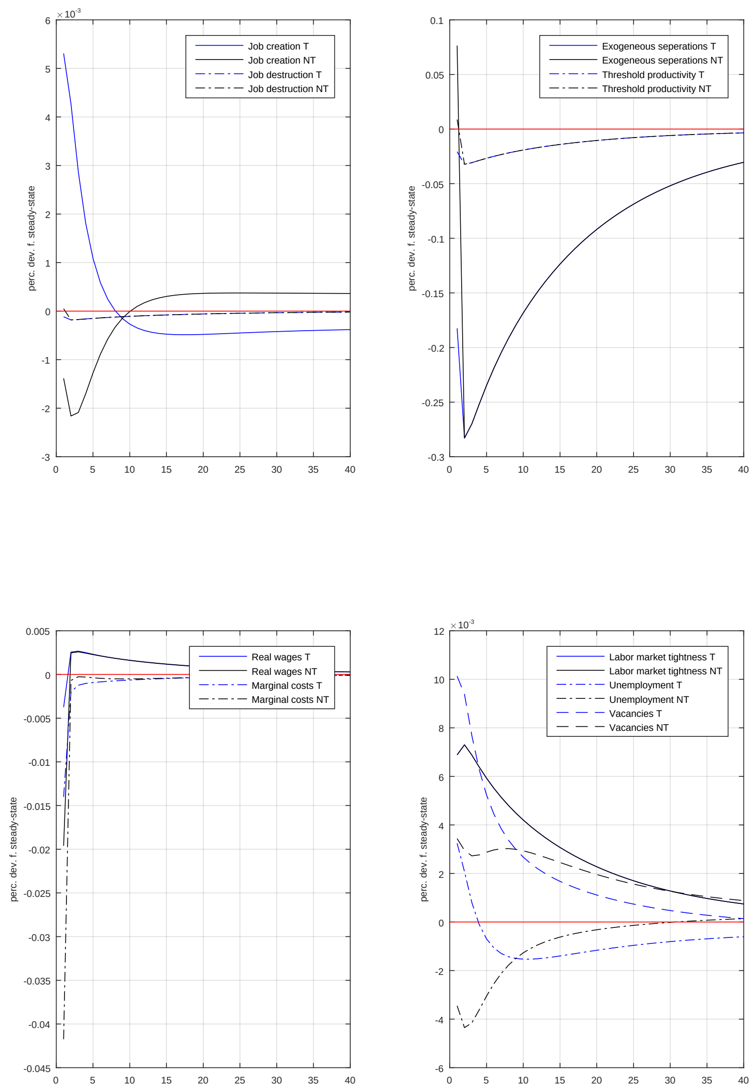
Impulse response functions to a positive technology shock in the domestic country. Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 2: Positive domestic technology shock



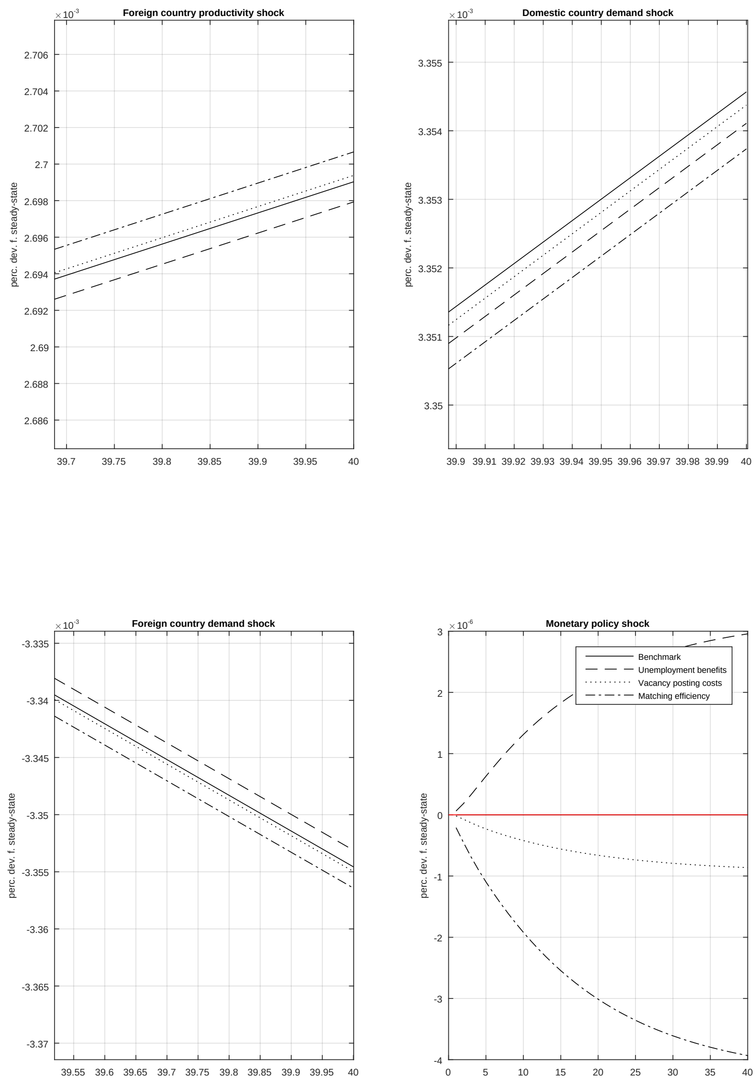
Impulse response functions to a positive technology shock in the domestic country. Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 3: Positive domestic productivity shock: labor market adjustment, benchmark case



Impulse response functions in the domestic country for the benchmark scenario. Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 4: Foreign debt of foreign country



Impulse response functions of the debt of the foreign country to various shocks. Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

6. Appendix

6.1. The log-linearized model

We now derive the log-linear equations for the domestic economy. A symmetric set of equations specifies the economy of the foreign country. The log-linearized version of the model is derived through a first-order Taylor approximation, while variables with a tilde denote the log-deviations from a deterministic steady-state. From the household's utility maximization, we can derive a log-linearized Euler equation

$$\tilde{c}_t = E_t\left\{\tilde{c}_{t+1}\right\} - \left(\tilde{r}_t - E_t\left\{\tilde{\pi}_{t+1}\right\} - \hat{\beta}_t\right),$$

and money demand from equation (8)

$$\tilde{m}_{Ht} - \tilde{p}_t = \sigma_m \tilde{y}_t + \left(\frac{1-\bar{\triangle}}{\bar{\triangle}}\right)\sigma_m\left(\hat{r}_t - \hat{r}_t^m\right),$$

where $\hat{\beta}_t$ denotes the log of the endogenous time-discount rate, $\tilde{\pi}_t \equiv \tilde{p}_t - \tilde{p}_{t-1}$ represents the log CPI inflation and the log differential in interest rates on assets and money is given by $\bar{\triangle} = 1 - \beta\left(1 - \bar{r}^m\right)$. The price of a consumption good bundle $\tilde{p}_t$ consists of prices for home-produced goods $\tilde{p}_{Ht}$ and goods produced in the rest of the currency union $\tilde{p}_{F,t}$. The log interest rate differential is given by $\hat{r}_t^m = \log\left(1 + \hat{r}_t^m / 1 + \bar{r}^m\right)$, with $\bar{r}^m$ being the steady-state zero inflation interest rate.

The endogenous discount factor depends negatively on consumption according to

$$\hat{\beta}_t = \varsigma_t - \psi\beta\tilde{c}_t,$$

where ς_t denotes an exogenous shock to the discount factor that obeys an autoregressive process. We, nevertheless, assume that ψ is small so that the effect is negligible on medium-term dynamics.

The demand of home tradables depends on the non-tradable to tradable price relation and on the terms of trade

$$\tilde{y}_{H,t} = \alpha(1-\alpha)\gamma\tilde{\tau}_t\Phi_1 + (1-\eta)\left[\alpha\tilde{x}_t\bar{\tau}^{\gamma-1} + (1-\alpha)\tilde{x}_t^*\bar{\tau}\right] + \alpha\tilde{c}_t\bar{\tau}^{\gamma-1} + (1-\alpha)\tilde{c}_t^*\bar{\tau}.$$

with $\Phi_1 \equiv \frac{1+\bar{\tau}^2}{\alpha+(1-\alpha)\bar{\tau}^{(1-\gamma)}}$. To derive this equation, we used the tradables consumption to aggregate consumption relation and equation (38). We derive the demand for non-tradables using the market clearing condition and the relation of non-tradables to aggregate consumption, which also depends on the non-tradables to tradables price relation

$$\tilde{y}_{N,t} = -\gamma\tilde{x}_t + \tilde{c}_t.$$

We now relate the terms of trade and the non-tradable to tradable price relation to CPI inflation and home prices for both domestic as well as foreign-produced tradable goods

$$\tilde{\tau}_t = \tilde{\tau}_{t-1} + (\triangle\tilde{q}_t + \tilde{\pi_{F,t}}^* - \tilde{\pi}_t) - (\tilde{\pi}_{H,t} - \tilde{\pi}_t),$$

$$\tilde{x}_t = \tilde{x}_{t-1} + \tilde{\pi}_{Nt} - \tilde{\pi}_{H,t} - \eta(1-\alpha)\triangle\tilde{\tau}_t.$$

The price of domestically produced goods, nevertheless, is subject to labor market imperfections. If we now log-linearize equation (29) around the steady-state, we can derive two New Keynesian Philips Curves

$$\tilde{\pi}_{H,t} = \beta E_t\tilde{\pi}_{H,t+1} + \frac{(1-\nu)(1-\nu\beta)}{\nu}\tilde{mc}_{T,t}, \tag{39}$$

$$\tilde{\pi}_{N,t} = \beta E_t\tilde{\pi}_{N,t+1} + \frac{(1-\nu)(1-\nu\beta)}{\nu}\tilde{mc}_{N,t}.$$

where $\tilde{mc}_{j,t}$ is defined as the log-deviation of marginal costs from their steady-state value μ. Marginal costs $\tilde{mc}_{j,t}$ are derived using a log-linear first-order approximation of Equation (35). In general, CPI depends on home and foreign prices as well as the terms of trade

$$\tilde{\pi}_t = \mu\tilde{\pi}_{H,t} + (1-\mu)\tilde{\pi}_{N,t} + \mu(1-\alpha)\triangle\tilde{\tau}_t.$$

Net exports depend on the difference of time-varying discount factors, the terms of trade and expected future net exports

$$\tilde{nx}_t = \frac{\bar{P}_F\bar{C}_F}{(1-\alpha)\bar{C}}\Big[(1-\alpha)\hat{\beta}_{R,t} - 2\alpha(1-\alpha)(\mu-1)E_t\triangle\tilde{\tau}_{t+1}\Big] + E_t\tilde{nx}_{t+1}.$$

Net indebtedness evolves from previous trade imbalances and net exports in the current period

$$\tilde{b}_t = \frac{1}{\beta}\tilde{b}_{t-1} + \tilde{nx}_t.$$

Given the indebtedness of the economy, we can express the current account as

$$\tilde{ca}_t = \tilde{b}_t - \frac{1}{1+g}\tilde{b}_{t-1},$$

with ca_t denoting the current account normalized by steady-state growth.

From the labor market equilibrium, we get the log-linear average real wage per sector

$$\tilde{w}_{j,t} = \frac{1}{\bar{w_j}} \left[\begin{array}{c} \eta \bar{mc}_j \bar{A}_j \frac{\bar{P}_j}{\bar{P}} \bar{a}_j \left(\tilde{mc}_{j,t} + \tilde{p}_{j,t} - \tilde{p}_t + \tilde{A}_{j,t} + \tilde{a}_{j,t} \right) \\ + c\bar{\theta}\tilde{\theta}_t + \tilde{T}_j \left(\bar{\omega_j}\tilde{\omega}_{j,t} + \beta(1-\rho^x)\tilde{\beta}_{t,t+1} \right) \end{array} \right]$$

with $\varrho = \frac{\eta \varepsilon A a}{w}$, the job creation condition

$$\tilde{\theta}_{j,t} = \frac{1}{\xi} \left[(1-\eta)\beta \bar{mc}_j (\bar{a_j}^N - \bar{\mathring{g}}) \left(\frac{\chi_j}{c_j \bar{\theta_j}^{\xi}} \right) E_t \Omega_1 + \tilde{\beta}_{t,t+1} \right], .$$

$$\Omega_1 = \left(\tilde{mc}_{jt+1} + p_{j,t} - p_t + \tilde{A}_{jt+1} - \frac{\bar{a}_i}{\bar{a}_j^N - \bar{\mathring{g}}} \tilde{\mathring{a}}_{jt+1} \right)$$

and the job destruction condition

$$\tilde{\theta}_{jt} = \left(\frac{\eta}{1\text{-}\eta} \right) c\theta\tilde{\theta}_t \left[\bar{mc}_j \bar{A}_j \frac{\bar{P}_j}{\bar{P}} \Omega_2 + \beta(1-\rho^x)\tilde{T}_j E_t \tilde{\beta}_{t,t+1} \right],$$

$$\Omega_2 = \left\{ \begin{array}{c} \bar{\mathring{g}} \left(\tilde{mc}_{j,t} + p_{j,t} - p_t + \tilde{A}_{j,t} + \tilde{\mathring{a}}_{j,t} \right) + \beta(1-\rho^x) \left(H(\bar{\mathring{g}}) - \bar{\mathring{a}}_j \right) \\ E_t \left(\tilde{\beta}_{t,t+1} + \tilde{mc}_{j,t+1} + \tilde{A}_{j,t+1} + \frac{\bar{\mathring{g}}}{H(\bar{\mathring{g}}) - \bar{\mathring{g}}} \tilde{\mathring{a}}_{j,t+1} \right) \end{array} \right\}$$

In our model, we assumed a currency union with a common monetary policy. In this case, the central bank targets inflation and output stability for the whole currency union

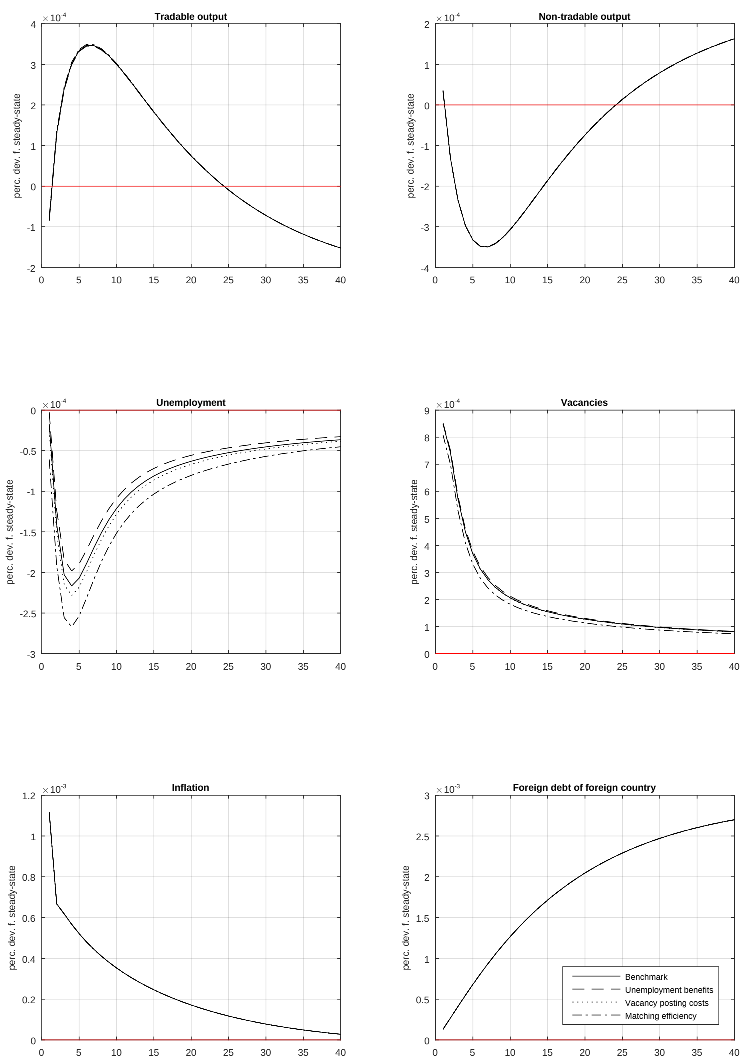
$$\tilde{r}_t = \rho_r \tilde{r}_{t-1} + \rho_y \left[\delta \tilde{y}_t^* + (1-\delta)\tilde{y}_t \right] + \rho_\pi \left(\delta \tilde{\pi}_t^* + (1-\delta)\tilde{\pi}_t \right) + \epsilon_{r_t}, \tag{40}$$

where δ attaches weights to the importance of the economy in the monetary policy function and $\epsilon_{r_t} \overset{i.i.d.}{\sim} N(0, \sigma_{r_t}^2)$ is a shock to monetary policy. The degree of interest rate smoothing ρ_r and the reaction coefficients to inflation and output, ρ_π and ρ_y, are all positive.

6.2. Tables supplement

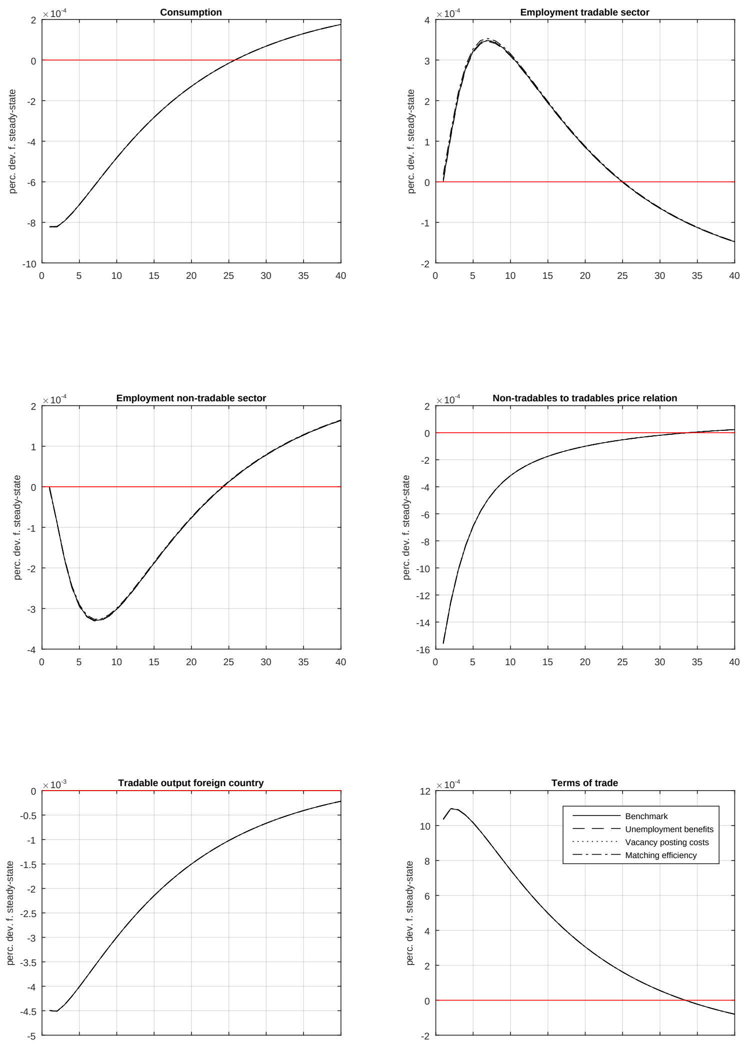
6.3. Figures supplement

Figure 5: Negative foreign technology shock



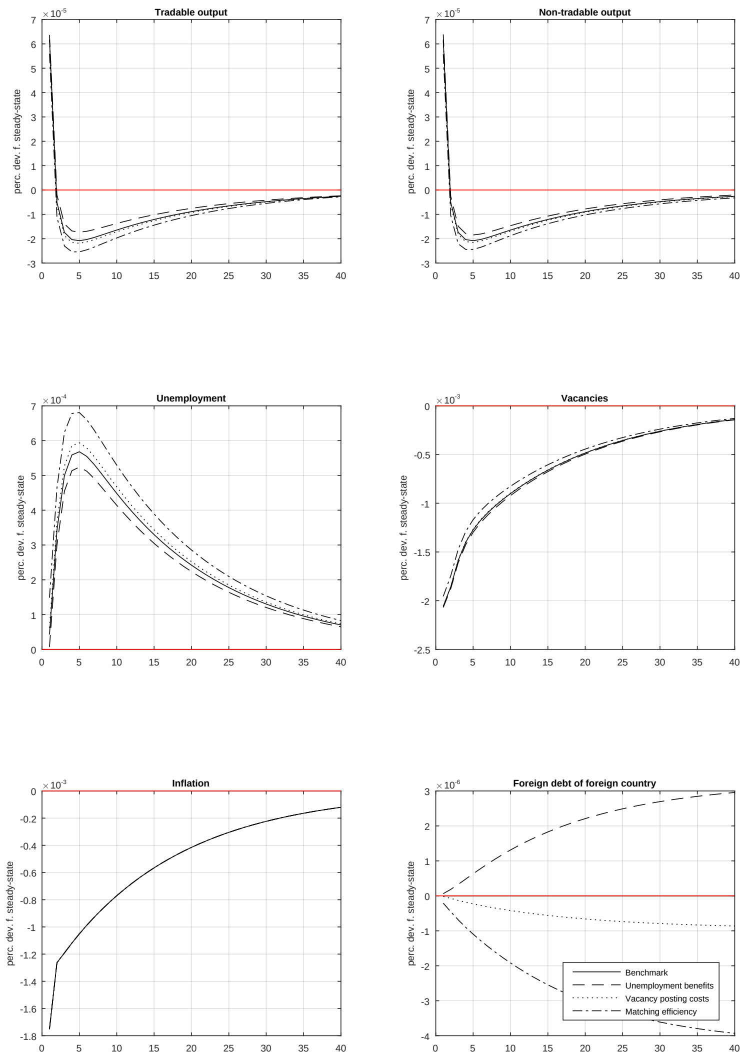
Impulse response functions to a negative technology shock in the foreign country. Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 6: Negative foreign technology shock



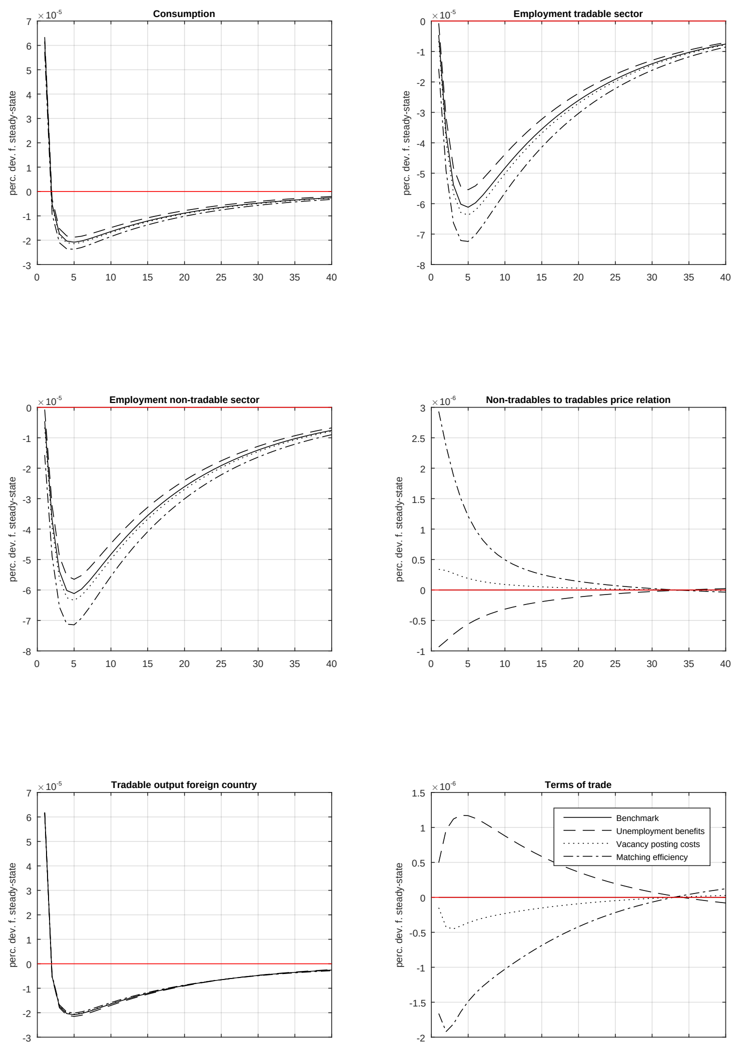
Impulse response functions to a negative technology shock in the foreign country. Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 7: Monetary policy shock



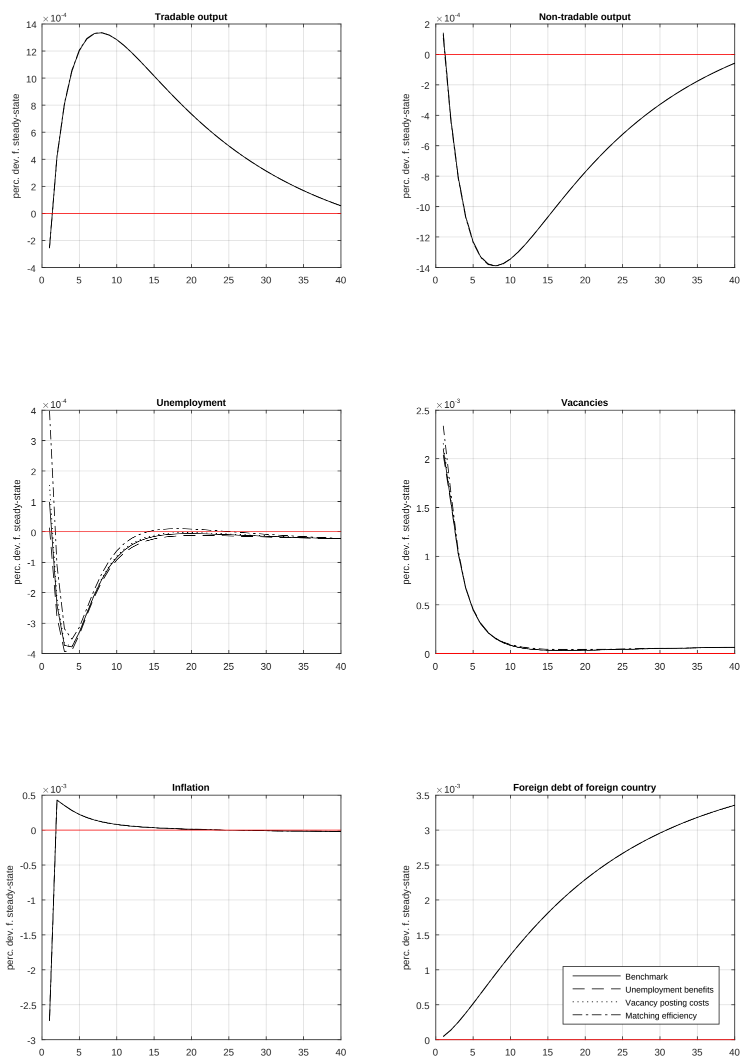
Impulse response functions to a monetary-policy and a time-preference shock in the union / domestic country.
Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 8: Monetary policy shock



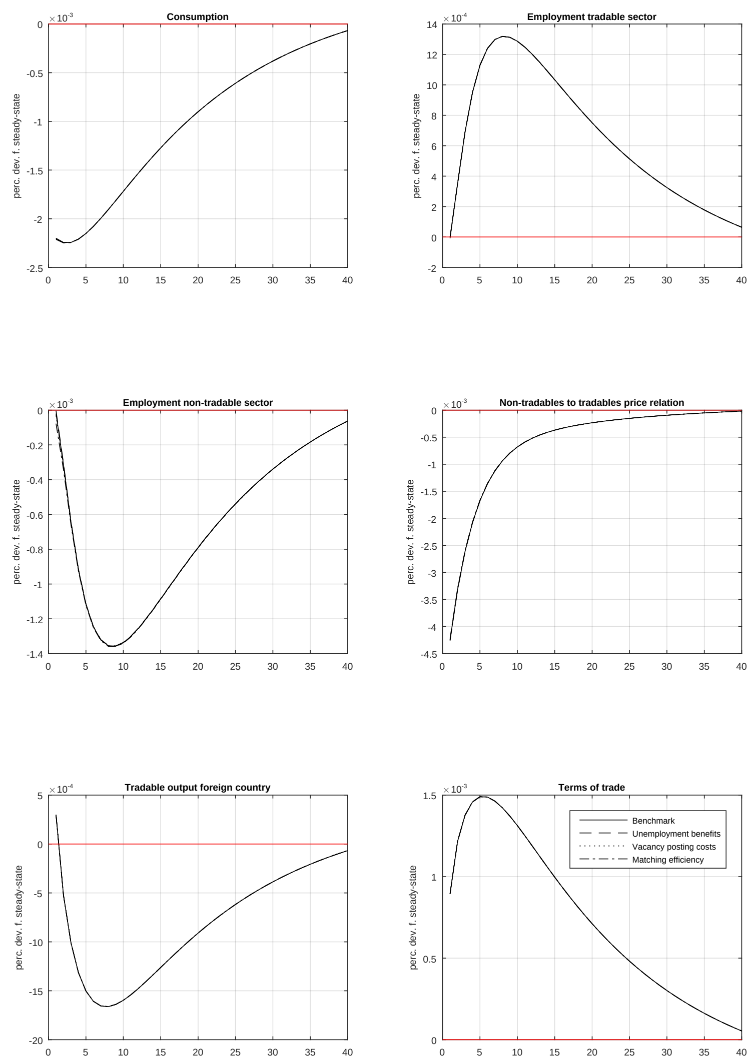
Impulse response functions to a monetary-policy and a time-preference shock in the union / domestic country.
Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 9: Time preference shock



Impulse response functions to a monetary-policy and a time-preference shock in the union / domestic country.
Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 10: Time preference shock



Impulse response functions to a monetary-policy and a time-preference shock in the union / domestic country.
Notes: Each panel shows the response of the model variables to a technology shock of one standard deviation. The horizontal axes measure time, expressed in quarters.

Figure 11: Sensitivity analysis (Income distribution)

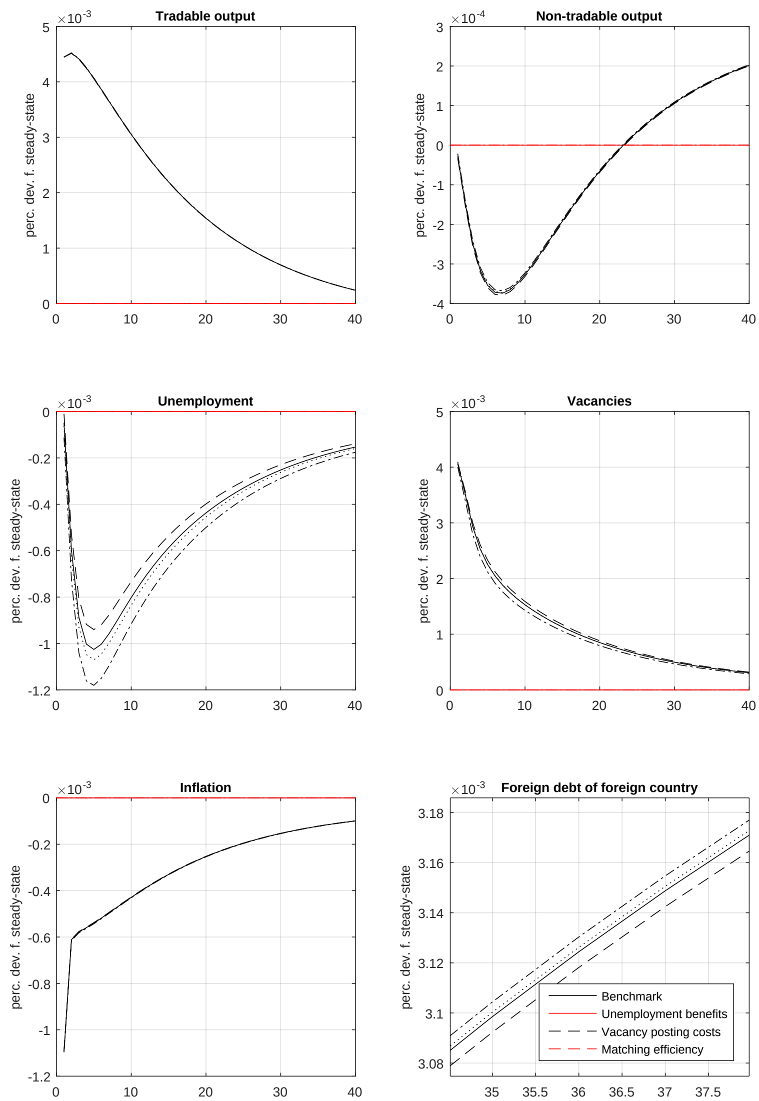


Figure 12: Sensitivity analysis (Income distribution)

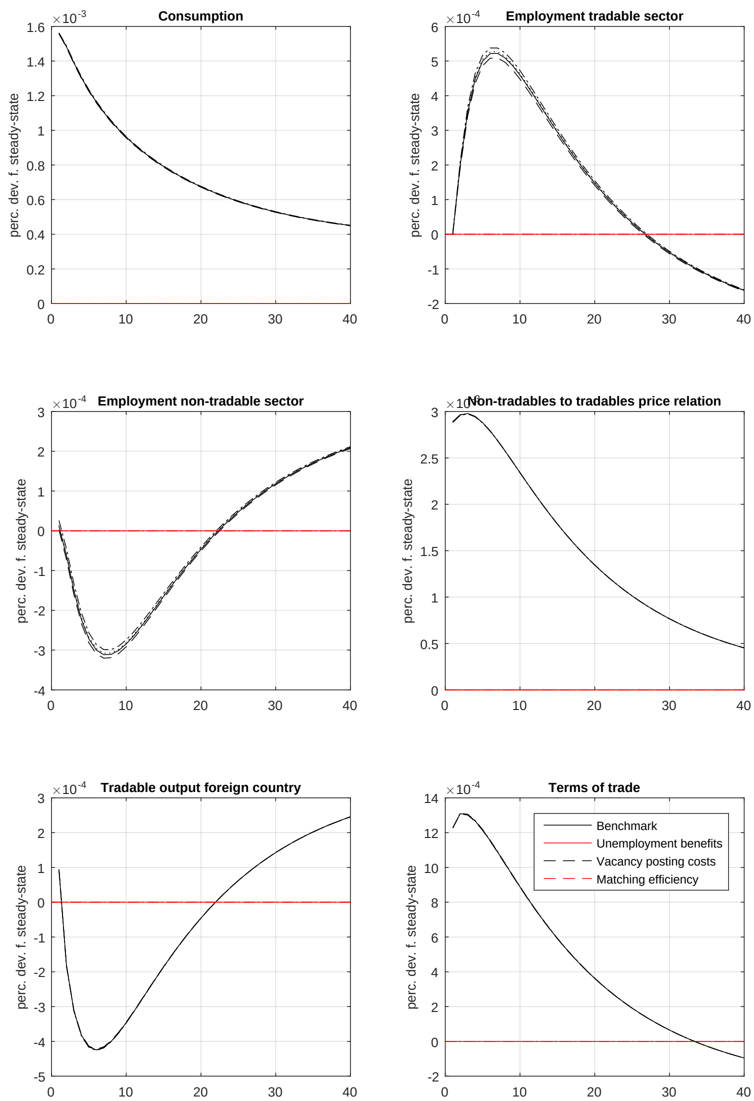


Figure 13: Sensitivity analysis (Low bargaining power)

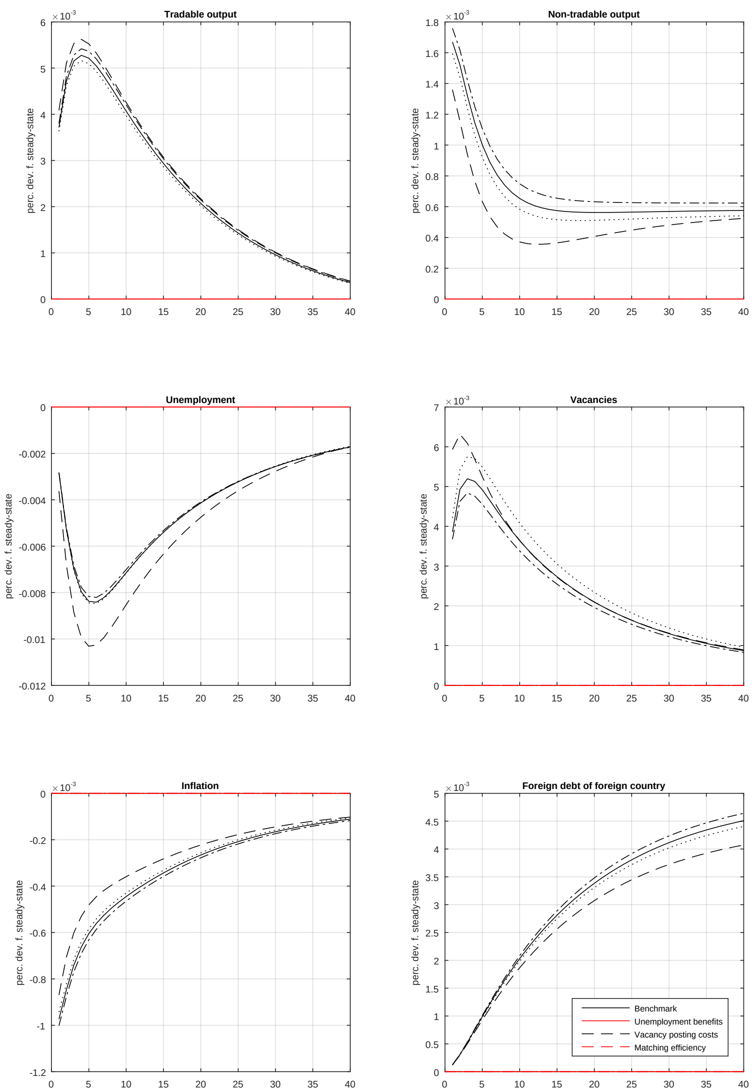


Figure 14: Sensitivity analysis (Low bargaining power)

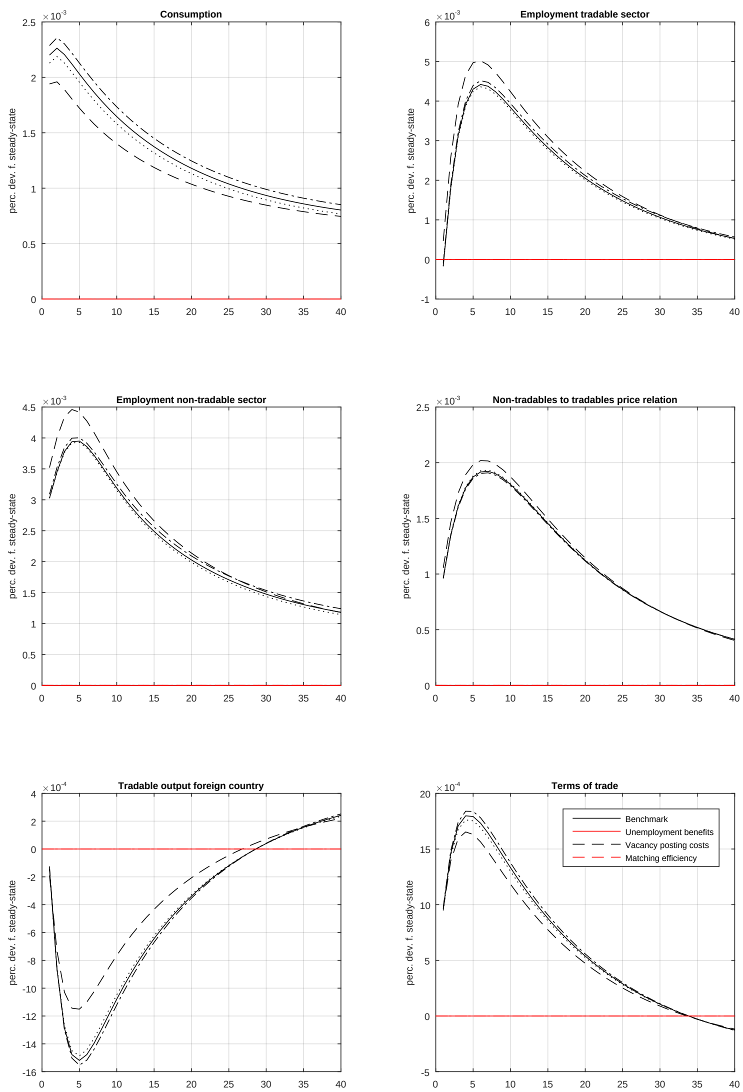


Table 3: Business cycle properties, all shocks

Variable	Euro Area	Benchmark Standard	Benchmark H-M	Sensitivity
GDP	0.0164	0.0164	0.0164	0.0164
Vacancies	0.1079	0.0485	0.0416	0.0478
Unemployment	0.0712	0.0126	0.0617	0.0117
Employment		0.0013	0.0371	0.0014
Inflation	0.0069	0.0497	0.0029	0.0495
Production	0.0241	0.0365	0.0155	0.0364
Employment	0.0057	0.0276	0.0265	0.0281
Vacancies		0.2104	0.0348	0.2153
Job searchers		0.1642	0.0739	0.1716
Real wage	0.0135	0.0889	0.0032	0.0902
Labor market tightness	0.1573	0.0531	0.1018	0.0517
Production	0.0109	0.0319	0.0276	0.0318
Employment	0.0072	0.0277	0.0514	0.0281
Vacancies		0.1412	0.0524	0.1491
Job searcher		0.1834	0.0502	0.1888
Real wage	0.0101	0.6656	0.0054	0.6604
Labor market tightness	0.1573	0.0531	0.1018	0.0517
Output, real wages T	0.8622	0.1666	0.9684	0.1444
Output, real wages NT	0.4381	0.0969	0.8992	0.0841
Output, Inflation	0.5433	0.0128	0.3349	0.0026
Real wages T, Inflation	0.3226	0.9738	0.4709	0.9746
Real wages NT, Inflation	-0.4357	0.9777	0.6105	0.9774
Unemployment, vacancies	-0.5766	-0.2511	-0.9408	-0.2273

Notes: Observed and simulated business cycle properties for the Eurozone (EA-12). The observed statistics are based on seasonally adjusted quarterly data from 2006:Q1 to 2012:Q2. Variables, except inflation, are transformed into logarithms. All the series are HP filtered (frequency 1600), so that only the cyclical component remains. The simulated business cycle statistics are based on 1000 simulations over 100 quarter horizon and are HP filtered for comparison purposes. Simulated figures are averages across simulations.