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Welfare Implications of Heterogeneous Labor Markets in a Currency Area[1]

Céline Poilly[2]

Banque de France

and THEMA-University of Cergy Pontoise

Jean-Guillaume Sahuc

Banque de France

and Audencia School of Management

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[2] *Corresponding author:* Banque de France, Economic and Financial Research Division, 31 rue Croix des Petits Champs, F-75049 Paris, France. E-Mail: `celine.poilly@banque-france.fr.`

Abstract

This paper investigates the role of labor markets heterogeneity in a monetary union and especially what are the welfare gains/costs of labor market reforms for each member of the area. To this end, we develop a medium-scale two-country model representing a currency union characterized by price and wage stickiness, real rigidities and labor market frictions. We make various scenarios of labor market reform and seek to determine the direction in which a country has an incentive to direct it from a welfare perspective. We find that the choice of the instrument to direct a reform (aiming at reducing the home unemployment rate) has drastic welfare implications in the union. Reforming the domestic labor market by a stronger regulation seems to give the best output. The analysis also shows that labor markets heterogeneity has sizeable effects on the amount of welfare gains, following a reform. The more flexible the foreign labor market, the higher its welfare. Finally, a sensitivity analysis shows that *(i)* the way the monetary authorities conduct their policy has negligible welfare effects but *(ii)* the size of a country in the monetary union is far to be neutral.

Keywords: DSGE model, currency union, heterogeneity, matching frictions, welfare.

JEL Codes: C3, C5.

Résumé

L'objectif de cet article est d'analyser le rôle de l'hétérogénéité des marchés du travail au sein d'une union monétaire. Précisément, nous examinons quels sont les gains (ou coûts) en bien-être social de mener une réforme sur le marché du travail d'un des membres de l'union. Pour ce faire, nous développons un modèle structurel d'une union monétaire contenant des prix et des salaires visqueux, un ensemble de rigidités réelles ainsi que des frictions sur le marché du travail. Plusieurs scénarios correspondant à une réforme particulière sur le marché du travail du pays domestique sont étudiés. Nous cherchons alors à déterminer d'un point de vue normatif quel serait le scénario préférable pour les membres de l'union monétaire. Nous montrons que le choix de l'instrument (*i.e.* du scénario), visant à réduire le taux de chômage du pays domestique, a des effets importants en termes de bien-être pour chaque pays de l'union. Les gains en bien-être sont les plus élevés lorsque nous considérons une plus forte régulation sur le marché du travail domestique. Cette analyse montre également que les implications en termes de bien-être d'une réforme dépendent du degré d'hétérogénéité des marchés du travail. Les effets sur le bien-être d'une réforme domestique pour le pays étranger seront positifs dès lors que le marché du travail de ce dernier est plus flexible. Enfin, des exercices de sensibilité montrent que *(i)* la façon dont les autorités monétaires conduisent leur politique a des effets négligeables sur le bien-être social alors que *(ii)* le poids des membres dans l'union joue un rôle important sur les conclusions obtenues.

Mots-clefs : Modèle DSGE, union monétaire, hétérogénéité, frictions sur le marché du travail, bien-être social.

Codes JEL : C3, C5.

Non-technical summary

Heterogeneity among the labor markets appears in single currency union, especially in the Euro Area. For instance, in 2006, the unemployment rate of the Netherlands or Ireland is low (resp. 3.9% and 4.4%) and rather high in France or Greece (resp. 9.5% and 8.9%). What does it imply? The aim of this paper is to study the role of labor markets heterogeneity in a monetary union and especially to know what are the welfare gains/costs of labor market reforms for each member of the area.

We develop a model of a two-country monetary union which resorts to the "New Open Economy Macroeconomics" literature. Each country characterized by some nominal and real rigidities (price and wage stickiness, habit formation, capital adjustment cost, for instance) which are known to improve the goodness-of-fit. In addition, so as to capture the salient features of the theory of involuntary unemployment, matching frictions are introduced in the two countries. The model is calibrated for the euro area by assuming that home and foreign countries are perfectly symmetric. However, heterogeneity among the labor markets is introduced by considering different combinations of calibration strategy for the labor market parameters.

Assuming that the model's labor market parameters can be affected through various structural policies, we seek to determine the direction in which a country has an incentive to direct its reforms, when the social planner aims at maximizing the social welfare. Therefore, we investigate which change in home labor market parameter could provide the weaker loss in order to achieve a (lower) home unemployment rate target. Therefore, we make various scenarios and elaborate which scenarios are preferable from a welfare perspective. We focus on three parameters related to the labor market structure: the job destruction rate, the matching efficiency, and the households' bargaining power. We assume a permanent shock on these structural parameters in order to achieve a lower home unemployment rate and we compute the social welfare gains/costs.

We find that the choice of the instrument to direct a reform (aiming at reducing the home unemployment rate) play a crucial role on the size of the social welfare gain in the union. Especially, the welfare gain is slightly higher by decreasing the job separation rate rather than by increasing the efficiency of the labor match. On the contrary, a decrease in the households' bargaining power leads to mitigate effects on the social welfare. In addition, the effects of a domestic reform on the "foreign welfare" depend on the characteristics of the foreign labor market. More particularly, the more flexible the foreign labor market, the higher the welfare gain. A sensitivity analysis also shows that the way the monetary authorities conduct their policy slightly influences the amount of the welfare gain, whatever the specification. Nevertheless, among different type of interest rate rules, using a rule including a strong reaction to inflation allows to obtain the largest welfare improvement in both home and foreign country. Finally, the size of a country in the monetary union plays an important role on the welfare effects. For example, if the foreign country with a flexible labor market has a small weight in the union, it can obtain a sizeable welfare loss following a domestic reform.

Résumé non technique

Au sein d'une union monétaire telle que la zone euro, l'hétérogénéité des marchés du travail est indéniable. Par exemple, en 2006, le taux de chômage des Pays-Bas ou de l'Ireland était faible (3.9% et 4.4%, respectivement) tandis qu'il était plutôt élevé en France ou en Grèce (9.5% et 8.9%, respectivement). Quelles sont les conséquences d'une telle hétérogénéité ? L'objectif de cet article est d'étudier le rôle de l'hétérogénéité des marchés du travail au sein d'une union monétaire. Précisément, nous examinons les implications en termes de bien-être social d'une réforme menée sur le marché du travail d'un des membres de l'union monétaire.

Nous considérons un modèle à deux pays évoluant dans une union monétaire, dans la lignée des modèles de la "Nouvelle Macroéconomie Ouverte". Le modèle comprend des rigidités nominales et réelles (prix et salaires visqueux, formation d'habitudes, coûts d'ajustement sur le capital, par exemple) qui lui permettent de reproduire la dynamique engendrée par les données. De plus, afin d'introduire une théorie du chômage involontaire dans le modèle, nous supposons que le marché du travail de chaque pays est guidé par un processus d'appariement frictionnel. Le modèle est étalonné pour la zone euro et les deux pays sont supposés parfaitement symétriques. Cependant, l'hétérogénéité entre les membres est introduite en considérant différentes combinaisons d'étalonnage des paramètres relatifs au marché du travail.

Nous supposons qu'une réforme se traduit par une politique structurelle faisant varier de façon permanente un paramètre du marché du travail du pays domestique. L'objectif est alors de déterminer quelle serait la réforme la plus avantageuse pour chaque pays en termes de bien-être social. Par conséquent, nous analysons le gain (ou coût) en bien-être de faire varier un paramètre spécifique au marché du travail. Nous nous focalisons sur trois paramètres particuliers : le taux de destruction d'emploi, l'efficacité d'appariement et le pouvoir de négociation des ménages. Nous supposons un choc permanent sur chacun de ces paramètres de façon à obtenir un taux de chômage domestique d'état stationnaire plus faible, puis calculons son implication en termes de bien-être.

Nous montrons que le choix de l'instrument (*i.e.* du paramètre), visant à réduire le taux de chômage d'état stationnaire du pays domestique, a des effets importants en termes de bien-être dans l'union. En effet, les plus forts gains en bien-être (dans les deux pays) sont obtenus en considérant une plus forte régulation sur le marché du travail domestique. Cette analyse montre également que les effets sur le bien-être social d'une réforme dépendent du degré d'hétérogénéité des marchés du travail. Les effets sur le bien-être du pays étranger seront positifs si son marché du travail est plus flexible que celui du pays domestique. Enfin, des exercices de sensibilité montrent que *(i)* la façon dont les autorités monétaires conduisent leur politique a des effets négligeables sur le bien-être social alors que *(ii)* le poids des membres dans l'union joue un rôle important sur les conclusions obtenues.

"It was the roaring economic growth of the European Economic Community, above all else, that made it such a success in its early days... Conversely, it was gloom about the economy, and particularly over persistent high unemployment, that played the biggest part in the rejection of the constitution and in the spread of Euroscepticism across the continent. If the European Union is to flourish far beyond its 50th birthday, it is its economy that most needs attention".

The Economist, March 15, 2007

Introduction

It is widely accepted that the euro area economy as a whole is characterized by real and nominal rigidities in most markets, disabling the labor market to function effectively. Indeed, average unemployment is persistently high (between 8% and 9% since 1999), average participation rate is low (around 69% since 1999) and real wages seem to be rather inflexible. The bad performance of the euro area labor market influences the well being of both the economy and society. A perfect flexibility of the labor market would imply that following any change in the economic environment, the labor force would be immediately redeployed to its most efficient use, with unemployment remaining at its structural level. However, there are many costs and impediments to such instantaneous adjustment, such as institutional features. It means that it should take more time for relative prices and quantities to fully reflect the new economic environment in the euro area than in other large areas.

Such frictions cannot be neglected and the understanding of labor market properties is of considerable importance for the conduct of monetary policy. Although recent fully-fledged models, like Christiano *et al.* (2005) and Smets and Wouters (2003, 2005), are successful at explaining a number of phenomena, their lack of implications about the labor market have lead researchers to depart from the competitive labor market hypothesis. For example, following the seminal contributions by Merz (1995) and Andolfatto (1996), some papers have attempted to incorporate labor market search and matching frictions in such New-Keynesian models (Moyen and Sahuc, 2005, Trigari, 2005, and Walsh, 2005).[1] They show that introducing these features improves the empirical performance of the closed-economy sticky-price model in several directions: *(i)* the existence of involuntary unemployment in equilibrium allows to reproduce the labor market stylized facts characterized by the Beveridge and Phillips curves; *(ii)* labor market frictions act as a necessary complement to nominal rigidities; *(iii)* monetary policy shocks can explain important features of labor market fluctuations.

However, in a single currency union, an additional difficulty due to the heterogeneity among the members appears. First, with a common currency, a low level of labor market flexibility is more costly within the area since neither independent monetary policy nor the exchange rate could be adjustment mechanisms in the face of asymmetric or symmetric economic shocks. For example, adjustment to a

[1] See, among others, Chéron and Langot (2004), Christoffel and Linzert (2005), Gertler and Trigari (2006), Bodart *et al.* (2006), and Krause and Lubik (2007b) for extensions, and Blanchard and Gali (2007), Faia (2008) and Thomas (2007) for recent optimal monetary policy applications.

country-specific or asymmetric shock may require a change in the real exchange rate and relative wages between countries to keep the adverse impact on unemployment and output to a minimum. Outside a currency union, this can be achieved either through an adjustment of the nominal exchange rate or an adjustment of factor and goods prices complemented by an appropriate monetary policy. Without the nominal exchange rate within a single currency, this would imply a less flexible economy. Second, as the monetary authorities take their decisions on the basis of aggregate developments, national idiosyncrasies are left to the care of national governments. Although the monetary authorities are interested on the aggregate variables, there are clearly disparities among the members. For example, in 2006, the unemployment rate of the Netherlands or Ireland is low (resp. 3.9% and 4.4%) and rather high in France or Greece (resp. 9.5% and 8.9%). What does it imply? The former group of countries spends a shorter period than the later group out of equilibrium or, in terms of the output gap, actual output remains closer to trend or potential. It would appear, therefore, that the more flexible are the labor markets the better.

Then, the key issue is not labor market flexibility *per se* since the common monetary policy can react to average responses in the union, but rather asymmetries across member countries. A body of evidence has discussed the effects of having disparities between the labor market institutions of different regions in a monetary union (Guichard and Laffargue, 2000, Hughes Hallett and Viegi, 2003, or Dellas and Tavlas, 2005). They show that a shock that initially has a symmetric effect across the monetary union will evolve into an asymmetric shock if the labor market of one region is more flexible than another and then it adjusts more rapidly. Nevertheless, Compolmi and Faia (2007) also show that a calibrated model of a monetary union with country-specific labor market institutions is able to replicate the data evidence.

To assess the need for structural labor market reforms, as stressed recurrently by the European Central Bank and recommended by the Lisbon Strategy (also known as the Lisbon Agenda)[2], it is necessary to investigate how labor markets will perform and interact into a monetary union. The issue is not only to know how the overall performance of the monetary union is affected by a modification of the frictions on the labor market, but also how the country-specific environment is modified and what are the implications in terms of welfare.[3]

The purpose of this paper is to study the role of labor markets heterogeneity in a monetary union and especially to know what are the welfare gains/costs of labor market reforms for each member of the area. We investigate which modification on the labor market structure (*i.e.* the labor market parameters) could provide the weaker loss in order to achieve a (low) unemployment rate target. We focus on three parameters related to the labor market structure: the job destruction rate, the matching efficiency, and the households' bargaining power. We assume a permanent shock on these structural

[2]The Lisbon strategy sets up the ambitious target for a Europe that would be *"the most competitive and dynamic knowledge-based economy in the world, capable of sustaining economic growth with more and better jobs and greater social cohesion"*.

[3]Jondeau and Sahuc (2008) have shown that forgetting structural heterogeneity of the members implies large and significant welfare losses in the euro area.

parameters in order to achieve a lower home unemployment rate and we compute the social welfare gains/costs. Therefore, we make various scenarios and elaborate which scenarios are preferable from a welfare perspective. To do so, we develop a model of a two-country monetary union which resorts to the "New Open Economy Macroeconomics" literature. By incorporating significant frictions in the form of nominal and real rigidities, such structural models have been shown to provide a sufficiently rich dynamics to fit the actual data fairly well. Cross-country differences in the structural parameters and home bias in preferences are incorporated in the model. Finally, the matching model is chosen as it may provide a simple and elegant representation of European labor market characteristics in capturing the salient features of the theory of involuntary unemployment.

The paper is organized as follows. In a first section, we describe the medium-scale monetary union model. A second section is devoted to the model's calibration. A third section analysis the welfare implications of heterogeneous labor markets in the monetary union. A last section offers some concluding remarks.

1 A model of a currency union

The world is composed of two countries, Home and Foreign (also denoted by $\mathcal{H}$ and $\mathcal{F}$ hereafter). The total population is ordered on a continuum of measure one. The population of country $\mathcal{H}$ belongs to $[0, n)$, while the foreign population belongs to $[n, 1]$. Therefore, n is the relative measure of the home country size into the union. An agent in the home country is indexed by $\mathcal{H} \in [0, n)$, while a foreign agent is indexed by $\mathcal{F} \in [n, 1]$. Variables in the home country are denoted X_t while foreign variables are denoted X_t^*. The home economy produces a continuum of differentiated goods indexed by $h \in [0, n)$. Foreign goods (or, equivalently, goods produced in the rest of the area) are indexed by $f \in [n, 1]$.

The two countries are part of a currency union so that monetary policy is chosen for the whole area.[4] Financial markets are assumed to be complete both at the national and international level. The labor market specification is based on the economics of search. Wages and hours worked are set by *Nash*-bargaining between households and wholesalers. In addition, we introduce wage rigidity by assuming that the inertia of wages is due to a social norm (Hall, 2005). Production of final goods takes place in two stages. Perfectly competitive wholesalers manage the production of the same homogeneous input good and make hiring decisions. Monopolistic retailers buy the input good to produce differentiated final goods sold by the households and set prices to the discrete time version of Calvo's (1983) model. Finally, households are assumed to have a taste bias towards home-produced goods. Since preferences differ across countries, the price of consumption bundles will differ when expressed in a common currency. The real exchange rate thus deviates from purchasing power parity (PPP).

This model extends Smets and Wouters (2003, 2005) on the labor market and openness features.

[4] An abundant literature has handled theoretical models in lines with the "New Open Economy Macroeconomics". See, for instance, Clarida *et al.* (2002), Smets et Wouters (2002), Benigno and Benigno (2003), Devereux and Engel (2003), Corsetti and Pesenti (2005) and Gali and Monacelli (2005).

However, the core of the model is identical such that it guarantees an acceptable goodness-of-fit. In addition, since the two countries are perfectly symmetric in the currency union, we only concentrate on the description of the home country side.

1.1 Households

The home economy is populated by a large number of infinitively-living identical households, consuming Dixit-Stiglitz aggregates of domestic and imported goods. A home household $\mathcal{H}$ owns a firm producing goods h and receives dividends from it. We assume that households in a given country have the same preferences and endowments, defined over a composite consumption good (C_t), the employment's rate (N_t) and hours worked (H_t). Although there may be idiosyncratic shocks among households, we assume that they have access to complete markets for state-contingent claims, so that there is no heterogeneity among agents in a given country. Consequently, all households in the same country behave in the same manner and then we consider the optimization problem of a representative household. The representative household in country $\mathcal{H}$ maximizes the following expected sequence of present and future utility flows given by[5]

$$\mathcal{U}_t = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\sigma_c}{\sigma_c - 1} (C_t - b\mathcal{C}_t)^{\frac{\sigma_c - 1}{\sigma_c}} - \upsilon N_t \left(\frac{\sigma_h}{\sigma_h + 1} H_t^{\frac{\sigma_h + 1}{\sigma_h}} \right) \right], \tag{1}$$

subject to a series of real period budget constraints

$$C_t + \frac{B_{t+1}}{(1 + R_t)P_t} + T_t \leq N_t W_t H_t + (1 - N_t)\Theta + \frac{B_t}{P_t} + \Pi_t, \tag{2}$$

where $\mathbb{E}_t$ denotes the expectation operator conditional on the information set at time t, β is the intertemporal discount factor, with $0 < \beta < 1$, $\upsilon > 0$ is a scale parameter, σ_c is the intertemporal elasticity of substitution of consumption, and σ_h is the elasticity of labor disutility with respect to hours worked. Preferences display external habit formation where the habit stock is supposed to equal the level of aggregate consumption in the previous period ($\mathcal{C}_t = C_{t-1}$), and b represents the habit persistence parameter, measuring the effect of past consumption on current utility ($0 \leq b < 1$). In addition, W_t is the hourly real wage, Θ is the unemployment benefits. Let P_t denote consumption price index (CPI), R_t is the nominal interest rate, T_t is the real lump sum tax and Π_t is the sum of the dividends derived from retailers (Π_t^r) and wholesalers (Π_t^w). Finally, we assume complete markets for state-contingent claims. Consequently, households can transfer wealth to the next period by holding B_{t+1} unit of the one-period nominal bond denominated in the domestic currency.

The maximization problem of the home household consists in maximizing equation (1) subject to constraint (2), yielding the optimal profile of consumption, holdings of domestic bond. The first-order

[5] The perfect insurance system makes the representative household a weighted average of employed and unemployed households, where the weight is the employment rate. That is why the employment rate enters the utility function and the budget constraint. By simplification we suppose that there is no disutility to search a job.

conditions imply[6]

$$\mathcal{U}_{C,t} = (C_t - b\mathcal{C}_t)^{-\frac{1}{\sigma_c}}, \tag{3}$$

$$(1+R_t)^{-1} = \beta \mathbb{E}_t \left[\frac{\mathcal{U}_{C,t+1}}{\mathcal{U}_{C,t}} \frac{P_t}{P_{t+1}} \right], \tag{4}$$

where $\mathcal{U}_{C,t}$ denotes the derivative of utility $\mathcal{U}$ with respect to variable C at the period t. Equation (3) defines the marginal utility of consumption. Equation (4) is the usual Euler equation for inter-temporal consumption flows. It establishes that the ratio of marginal utility of future and current consumption is equal to the inverse of the real interest rate.

1.1.1 Composite consumption index

The aggregate consumption index for home households and the corresponding consumption index for foreign households are defined by

$$C_t = \frac{(C_{\mathcal{H},t})^{\omega}(C_{\mathcal{F},t})^{1-\omega}}{\omega^{\omega}(1-\omega)^{1-\omega}} \qquad \text{and} \qquad C_t^* = \frac{(C^*_{\mathcal{H},t})^{\omega^*}(C^*_{\mathcal{F},t})^{1-\omega^*}}{(\omega^*)^{\omega^*}(1-\omega^*)^{1-\omega^*}}, \tag{5}$$

where ω and ω^* denote the share of home goods in the consumption of home and foreign households respectively. $C_{\mathcal{H},t}$ (resp. $C_{\mathcal{F},t}$) is the sub-index of consumption of imperfectly substitutable, home (resp. foreign) goods, which is in turn given by the following CES aggregators

$$C_{\mathcal{H},t} = \left[\left(\frac{1}{n}\right)^{\frac{1}{\varepsilon_p}} \int_0^n C_t(h)^{\frac{\varepsilon_p - 1}{\varepsilon_p}} \mathrm{d}h \right]^{\frac{\varepsilon_p}{\varepsilon_p - 1}} \quad \text{and} \quad C_{\mathcal{F},t} = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\varepsilon_p}} \int_n^1 C_t(f)^{\frac{\varepsilon_p - 1}{\varepsilon_p}} \mathrm{d}f \right]^{\frac{\varepsilon_p}{\varepsilon_p - 1}}, \tag{6}$$

where $C_t(h)$ (resp. $C_t(f)$) is consumption of the generic good h (resp. f) produced in country $\mathcal{H}$ (resp. $\mathcal{F}$). Parameter ε_p denotes the elasticity of substitution across goods produced within a given country. The corresponding consumption price indexes are given by

$$P_t = (P_{\mathcal{H},t})^{\omega}(P_{\mathcal{F},t})^{1-\omega} \qquad \text{and} \qquad P_t^* = (P^*_{\mathcal{H},t})^{\omega^*}(P^*_{\mathcal{F},t})^{1-\omega^*}. \tag{7}$$

Here, $P_{\mathcal{H},t}$ (resp. $P_{\mathcal{F},t}$) is the price sub-index for home- (resp. foreign-) produced goods expressed in the home currency, defined as

$$P_{\mathcal{H},t} = \left[\frac{1}{n} \int_0^n P_{\mathcal{H},t}(h)^{1-\varepsilon_p} \mathrm{d}h \right]^{\frac{1}{1-\varepsilon_p}} \qquad \text{and} \qquad P_{\mathcal{F},t} = \left[\frac{1}{1-n} \int_n^1 P_{\mathcal{F},t}(f)^{1-\varepsilon_p} \mathrm{d}f \right]^{\frac{1}{1-\varepsilon_p}},$$

where $P_{\mathcal{H},t}(h)$ (resp. $P_{\mathcal{F},t}(f)$) is the price of a generic good h (resp. f) produced in country $\mathcal{H}$ (resp. $\mathcal{F}$).

We also assume that prices are set in the producer's currency and that the law of one price holds. We then have $P_{\mathcal{H},t}(h) = P^*_{\mathcal{H},t}(h) S_t$ and $P_{\mathcal{F},t}(f) = P^*_{\mathcal{F},t}(f) S_t$, where S_t is the nominal exchange rate expressed as units of domestic currency needed for one unit of foreign currency. Under the currency

[6] We abstract here from the optimal intra-temporal allocations between domestic and foreign goods.

union assumption the nominal exchange rate is equal to one ($S_t = 1$). Since we assume the same elasticity of substitution among goods in a given country, we also have $P_{\mathcal{H},t} = P^*_{\mathcal{H},t}$ and $P_{\mathcal{F},t} = P^*_{\mathcal{F},t}$. Yet, from the definition of the CPI, we obtain that

$$\frac{P_t}{P^*_t} = \left(\frac{P_{\mathcal{H},t}}{P_{\mathcal{F},t}}\right)^{\omega-\omega^*}.$$

Therefore, if we assume that there exists a home bias in preferences ($\omega \neq \omega^*$), PPP does not necessarily hold, i.e. $P_t \neq P^*_t$. We expect $\omega > \omega^*$, so that home households put a higher weight on home goods than foreign households.

1.1.2 International risk sharing

Under the assumption of complete markets, domestic and foreign households trade in state-contingent claims denominated in the home currency. This implies the following perfect risk-sharing condition (Chari *et al.*, 2002)

$$Q_t = \kappa \frac{\mathcal{U}^*_{C^*,t}}{\mathcal{U}_{C,t}}, \tag{8}$$

where the real exchange rate, defined as $Q_t \equiv S_t P^*_t / P_t$, is proportional to the ratio of the marginal utility of consumption between the two countries.[7]

Since the real exchange rate deviates from PPP because of home bias in preferences, we also have

$$Q_t = \left(\frac{P^*_{\mathcal{H},t}}{P_{\mathcal{H},t}}\right)^{\omega^*} \left(\frac{P^*_{\mathcal{F},t}}{P_{\mathcal{F},t}}\right)^{1-\omega^*} \left(\frac{P_{\mathcal{F},t}}{P_{\mathcal{H},t}}\right)^{\omega-\omega^*} = (\mathcal{T}_t)^{\omega-\omega^*}, \tag{9}$$

where $\mathcal{T}_t$ is the home terms of trade, i.e. the relative price between foreign and home bundles of goods as perceived by the home resident. It is defined as[8]

$$\mathcal{T}_t = \frac{P_{\mathcal{F},t}}{P_{\mathcal{H},t}} = \frac{P^*_{\mathcal{F},t}}{P^*_{\mathcal{H},t}}. \tag{10}$$

From equalities (7), we easily deduce that

$$\pi_t = \pi_{\mathcal{H},t}\left[\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}}\right]^{1-\omega} \qquad \text{and} \qquad \pi^*_t = \pi_{\mathcal{F},t}\left[\frac{\mathcal{T}_{t-1}}{\mathcal{T}_t}\right]^{\omega^*},$$

where π_t and π^*_t are the *CPI* inflation rate in the home and the foreign country, respectively. In addition, $\pi_{\mathcal{H},t}$ and $\pi_{\mathcal{F},t}$ are *domestic* inflation rate in the home and the foreign country, respectively, defined as the inflation of the index of domestic goods prices. Using equations (10), (3), (8) and (9), we obtain

$$(\mathcal{T}_t)^{\omega-\omega^*} = \kappa \frac{(C_t - bC_{t-1})^{\sigma_c}}{\left(C^*_t - b^* C^*_{t-1}\right)^{\sigma^*_c}}. \tag{11}$$

[7] $\kappa = [S_0 P^*_0 \mathcal{U}_{C,0}]/[P_0 \mathcal{U}^*_{C^*,0}]$ is a constant that depicts initial condition.

[8] The foreign terms of trade are simply given by $\mathcal{T}^*_t = P^*_{H,t}/P^*_{F,t} = 1/\mathcal{T}_t$, because the law of one price holds.

Equation (11) provides a rather elegant way to escape the exchange rate non-stationarity and model indeterminacy issues. Note that, when there is no home bias in preferences ($\omega = \omega^*$), the perfect risk sharing assumption does not allow to determine the terms of trade anymore.

1.2 Labor market matching of the home country

At the macroeconomic level, the law of motion of aggregate employment (N_t) is

$$N_{t+1} = (1 - s)N_t + M_t, \tag{12}$$

where $s \in (0, 1)$ denotes the job separation rate. Therefore, proportion s of all filled jobs disappears at each instant, and M_t is the mass of recruiting at period t.[9] Thus, matching which take place at the period t are only productive at the following period.

The matching function is a very convenient hypothetical concept whose basic idea is that the recruiting effort of employers and the search effort of workers serve as inputs in a market matching function that generates new hires.[10] The job vacancies (V_t) and unemployed workers (U_t) are randomly matched with each other. The aggregate flow of job matches are deterministic and given by the following matching technology

$$M_t = \tilde{m} U_t^{\vartheta} V_t^{1-\vartheta}, \tag{13}$$

where $\vartheta \in (0, 1)$ denotes the unemployment elasticity to the matching function and $\tilde{m} > 0$ is a scale parameter. The matching technology exhibits constant return to scale. We choose a Cobb-Douglas form for its simplicity. The labor force being normalized to one, the number of unemployed workers at the beginning of any given period is $U_t = 1 - N_t$.

The job vacancies and unemployed workers that are matched together in period t are randomly selected from the sets V_t and U_t. Hence, the stochastic process governing the state of vacant jobs during an interval of time is Poisson with rate

$$\tau_t = \frac{M_t}{V_t}. \tag{14}$$

In other words, τ_t can be interpreted as the instantaneous probability of a vacancy being filled. Also, the average steady-state duration of a job vacancy is $1/\bar{\tau}$.

Similarly, the instantaneous probability that an unemployed worker finds a vacant position is given by

$$\varrho_t = \frac{M_t}{U_t}, \tag{15}$$

[9] To simplify the analysis, we ignore any endogenous separation. Hall (2005) has argued that the separation rate varies little over the business cycle, although part of the literature disputes this position.

[10] Firms have jobs that are filled or vacant and workers have a job or are unemployed but only the vacant jobs are offered and unemployed people are engaged in search. This assumption implies that the two activities of production of goods and trade in labour market are strictly separate activities.

which means that the average steady-state duration of unemployment is $1/\bar{\varrho}$. Recall that the labor market specification is identical in the foreign country.

1.3 The production sector in the domestic and the foreign country

Production of final goods in each country takes place in two stages. First, perfectly competitive wholesalers manage the production of the same homogenous input good and make investment and hiring decisions. Second, there is a continuum of infinitely living and monopolistic retailers indexed by h on the interval $[0, n)$ for the home country and by f on the interval $[n, 1]$ for the foreign country. They buy the input good to produce differentiated goods which are bundled into homogeneous home and foreign goods by constant returns to scale of the Dixit-Stiglitz form

$$Y_t = \left[\left(\frac{1}{n}\right)^{1/\varepsilon_p} \int_0^n Y_t(h)^{\frac{\varepsilon_p - 1}{\varepsilon_p}} \mathrm{d}h\right]^{\frac{\varepsilon_p}{\varepsilon_p - 1}} \quad \text{and} \quad Y_t^* = \left[\left(\frac{1}{1-n}\right)^{1/\varepsilon_p} \int_n^1 Y_t^*(f)^{\frac{\varepsilon_p - 1}{\varepsilon_p}} \mathrm{d}f\right]^{\frac{\varepsilon_p}{\varepsilon_p - 1}}.$$

In addition, they set prices according to the discrete time version of Calvo's (1983) model. Since, the maximization problems which characterize the production sector are symmetric across the two economies, we present only the ones for the home region.

1.3.1 Wholesalers

We consider a representative firm in each country which acts on a perfect competition market and makes investment and hiring decisions. Each period, this firm uses physical capital (K_t) and labor (total hours, $N_t H_t$) as inputs in order to produce a homogeneous wholesale good (Y_t^w) which cannot be consumed and will be sold to retailers at relative price $MC_t = P_t^w / P_t$ to produce a differentiated final good. The production technology is given by

$$Y_t^w = (z_t K_t)^{\phi} (N_t H_t)^{1-\phi}, \tag{16}$$

where $\phi \in (0, 1)$ is the elasticity of value added with respect to capital, z_t is the capital utilization rate. For computational convenience, we assume constant return to scale.

The modelling of investment can be linked to Tobin's Q-model, which couples investment decisions to forward-looking stock market valuations of the firm. This model can be derived from the theory if it is assumed that investment is subject to adjustment costs, which are a convex function of the rate of change of the firm's capital stock. The firm's stock of physical capital evolves according to

$$K_{t+1} = (1 - \delta(z_t)) K_t + I_t, \tag{17}$$

where I_t denotes time t purchases of investment goods and $\delta(z_t)$ a positive, increasing and convex

function of the utilization rate defined by

$$\delta(z_t) = \tilde{\delta}\frac{z_t^d}{d}, \tag{18}$$

that reflects the fact that a higher utilization rate raises the depreciation rate of capital (with $d > 1$). $\tilde{\delta} > 0$ is a scale parameter. The functional form chosen here for the adjustment costs is given by

$$A_t = A(I_t, K_t, z_t) = \frac{\varpi}{2}\left(\frac{I_t}{K_t} - \delta(z_t)\right)^2 K_t, \tag{19}$$

with $\varpi > 0$.

The representative firm chooses sequences of vacancies, investment, and utilization rate in order to maximize the expected sum of discounted profits, taking as given a per vacancy cost (η),

$$\mathbb{E}_t \sum_{t=0}^{\infty} \Upsilon_{t,t+j}\Big[MC_t\left(z_t K_t\right)^{\phi}\left(N_t H_t\right)^{1-\phi} - W_t N_t H_t - \eta V_t - (I_t + A_t)\Big],$$

subject to the following constraints

$$N_{t+1} = (1-s)N_t + \tau_t V_t, \tag{20}$$

$$K_{t+1} = (1-\delta(z_t))K_t + I_t. \tag{21}$$

and with $\Upsilon_{t,t+j} = \beta^j \mathcal{U}_C(C_{t+j})/\mathcal{U}_C(C_t)$ is the discount factor between time t and $t+j$.

The first-order conditions of this program are given by[11]

$$\frac{\eta}{\tau_t} = \mathbb{E}_t\left[\Upsilon_{t,t+1}\left((1-\phi)MC_{t+1}\frac{Y_{t+1}^w}{N_{t+1}} - W_{t+1}H_{t+1} + (1-s_t)\frac{\eta}{\tau_{t+1}}\right)\right], \tag{22}$$

$$1 + A_{I_t} = \mathbb{E}_t\left[\Upsilon_{t,t+1}\left(\phi MC_{t+1}\frac{Y_{t+1}^w}{K_{t+1}} - A_{K_{t+1}} + (1-\delta(z_{t+1}))\left(1 + A_{I_{t+1}}\right)\right)\right], \tag{23}$$

$$\phi MC_t\frac{Y_t^w}{z_t} = K_t\delta_{z_t}. \tag{24}$$

1.3.2 Wage and hours determination

As previously, we present only the labor decisions for the home country since sectors are symmetric across the two economies. In each country, wage and hours worked are determined by the generalized *Nash*-bargaining solution. Indeed, the matching between an unemployed person and a firm who coordinate each other gives rise to a surplus which must be shared between the meeting pair. This sharing takes place at the match level through a bilateral and decentralized wage/hours negotiation. Knowing that there are a representative household and a representative firm, we are located directly

[11] Let A_{x_t} denote the first derivative of A_t with respect to x_t, where $x_t = \{I_t, K_t, z_t\}$ and δ_{z_t} denotes the first derivative of $\delta(z_t)$ with respect to z_t.

at the symmetric equilibrium solution of the model.

Formally, the surplus generated by a successful match between an unemployed worker and a vacant job is the marginal value of employment. One can show that hourly real wage is given by

$$W_t^{\star} = \xi \left[(1-\phi)\, MC_t \frac{Y_t^w}{H_t N_t} + \frac{\eta \bar{\nu}}{H_t} \right] + (1-\xi) \left[\frac{\sigma_h}{1+\sigma_h} \frac{\upsilon H_t^{\frac{1}{\sigma_h}}}{\mathcal{U}_{C,t}} + \frac{\Theta}{H_t} \right],$$

where $\xi \in [0,1]$ is the relative bargaining power of households and $\bar{\nu} \equiv \bar{V}/\bar{U}$ measures the tightness of the labor market.

In addition, in order to avoid a too large procyclicity of wages, we introduce wage rigidities into the model in the form of a backward looking social norm (Hall, 2005).[12] Precisely, we assume that the individual real wage is a weighted average of the one obtained thought the *Nash*-bargaining process and a wage norm which is set independently of idiosyncratic conditions. Consequently, the real wage paid in job is defined by

$$W_t = (W_t^{\star})^{(1-\alpha_w)}\, \check{W}^{\alpha_w},$$

where $\check{W}$ is the wage norm, $\alpha_w \in [0,1]$ is the adjustment rate. Following Hall (2005), we adopt the adaptive wage specification such that $\check{W} = W_{t-1}$.

Finally, hours worked are determined by maximizing the joint surplus and are given by[13]

$$(1-\phi)^2 \frac{MC_t Y_t^w}{N_t} = \frac{\upsilon H_t^{\frac{1}{\sigma_n}}}{\mathcal{U}_{C,t}}. \tag{25}$$

1.3.3 Retailers

There is a continuum of monopolistically competitive retailers indexed by h on the interval $[0,n)$. Each of them is infinitively lived and produces a differentiated final good $Y_t(h)$ with a technology that transforms one unit of wholesale goods into one unit of retail goods, so that $Y_t(h) = Y_t^w(h)$. Firms on the retail sector purchase output from wholesale producers at the price MC_t (which becomes the firm's real marginal cost) and directly sell to households.[14]

Retailers' price setting decision is modelled through the Calvo's (1983) staggering mechanism. In addition to the baseline mechanism, we allow for the possibility that firms that do not optimally set their prices may nonetheless adjust it to keep up with the previous period increase in the general price level. In each period, a firm faces a constant probability, $1-\alpha_p$, of being able to re-optimize its price

[12] In the standard matching frictions model, real wages are too procyclical since they are directly driven by the dynamics of output. This implies a too less volatility of employment.

[13] Rather than assuming that hours worked and real wages are determined simultaneously, we could have assumed that firms choose hours worked, by taking the bargained real wage as given. This "right to manage" assumption (see Trigari, 2006) introduces a additional channel from the real wages to the real marginal cost and inflation.

[14] For the sake of simplicity, we assume that the government and the wholesaler have the same optimal intratemporal allocations for each differentiated goods as the household.

and chooses the new price $P^{\star}_{\mathcal{H},t}(h)$ that maximizes the expected discounted sum of profits

$$\mathbb{E}_t \sum_{j=0}^{\infty} \alpha_p^j \Upsilon_{t,t+j} \left[\frac{P^{\star}_{\mathcal{H},t}(h)\, \Psi^{\mathcal{H}}_{t,t+j}(1+tax)}{P_{\mathcal{H},t+j}} - MC_{t+j} \right] Y_{t+j}(h), \tag{26}$$

subject to the sequence of demand equations

$$Y_{t+j}(h) = \left(\frac{P^{\star}_{\mathcal{H},t}(h)\, \Psi^{\mathcal{H}}_{t,t+j}}{P_{\mathcal{H},t+j}} \right)^{-\varepsilon_p} Y_{t+j}, \tag{27}$$

with

$$\Psi^{\mathcal{H}}_{t,t+j} = \begin{cases} \prod_{\nu=0}^{j-1} \bar{\pi}_{\mathcal{H}}^{1-\gamma_p} \pi_{\mathcal{H},t+\nu}^{\gamma_p} & j > 0 \\ 1 & j = 0, \end{cases} \tag{28}$$

where $\bar{\pi}_{\mathcal{H}}$ is the domestic trend inflation, the coefficient $\gamma_p \in [0,1]$ indicates the degree of indexation to past inflation during the periods in which firm is not allowed to re-optimize. Finally, $\Psi^{\mathcal{H}}_{t,t+j}$ is a correcting term that accounts for the fact that, if firm h does not re-optimize its price, it updates it according to the rule

$$P_{\mathcal{H},t}(h) = \left(\bar{\pi}_{\mathcal{H}}\right)^{1-\gamma_p} \left(\pi_{\mathcal{H},t-1}\right)^{\gamma_p} P_{\mathcal{H},t-1}(h). \tag{29}$$

Consequently, the first-order condition associated to the profit maximization implies that firms set their price equal to the discounted stream of expected future real marginal costs

$$p^{\star}_{\mathcal{H},t}(h) = \mu_p \frac{\mathbb{E}_t \sum_{j=0}^{\infty} \alpha_p^j \Upsilon_{t,t+j} \left(\frac{\Psi^{\mathcal{H}}_{t,t+j} P_{\mathcal{H},t}}{P_{\mathcal{H},t+j}} \right)^{-\varepsilon_p} Y_{t+j} MC_{t+j}}{\mathbb{E}_t \sum_{j=0}^{\infty} \alpha_p^j \Upsilon_{t,t+j} (1+tax) \left(\frac{\Psi^{\mathcal{H}}_{t,t+j} P_{\mathcal{H},t}}{P_{\mathcal{H},t+j}} \right)^{1-\varepsilon_p} Y_{t+j}}, \tag{30}$$

where $p^{\star}_{\mathcal{H},t}(h)$ is the relative price of domestic goods and $\mu_p \equiv \varepsilon_p / (\varepsilon_p - 1)$ is the optimal markup in a flexible-price economy. In order to eliminate monopoly distortions, we assume that producers of intermediate goods are subsidized at rate tax such that $(1+tax) = \mu_p$. As there are no firm-specific shocks in this economy, all firms that are allowed to re-optimize their price at date t select the same optimal price $p^{\star}_{\mathcal{H},t}(h) = p^{\star}_{\mathcal{H},t}$, $\forall h$.

Staggered price setting under partial indexation implies the following expression for the evolution of the domestic price index

$$P_{\mathcal{H},t} = \left[\alpha_p \left(\left(\bar{\pi}_{\mathcal{H}}\right)^{1-\gamma_p} \left(\pi_{\mathcal{H},t-1}\right)^{\gamma_p} P_{\mathcal{H},t-1} \right)^{1-\varepsilon_p} + (1-\alpha_p) \left(P^{\star}_{\mathcal{H},t} \right)^{1-\varepsilon_p} \right]^{\frac{1}{1-\varepsilon_p}}. \tag{31}$$

The price setting problem solved by firms in the foreign country is similar and leads to an optimal rule analogous to equation (31).

1.4 Market clearing conditions

Domestic and foreign outputs may be either transformed into a single type of consumption good, invested, consumed by the government and used up in vacancy posting costs or capital adjustment cost. The allocation of demand across each of the goods produced within a given country for consumers $\mathcal{H}, \mathcal{F}$ are then given by

$$\begin{aligned} X_t(h) &= \frac{1}{n}\left(\frac{P_{\mathcal{H},t}(h)}{P_{\mathcal{H},t}}\right)^{-\varepsilon_p} X_{\mathcal{H},t} \qquad \text{and} \qquad X_t^*(h) = \frac{1}{n}\left(\frac{P^*_{\mathcal{H},t}(h)}{P^*_{\mathcal{H},t}}\right)^{-\varepsilon_p} X^*_{\mathcal{H},t}, \\ X_t(f) &= \frac{1}{1-n}\left(\frac{P_{\mathcal{F},t}(f)}{P_{\mathcal{F},t}}\right)^{-\varepsilon_p} X_{\mathcal{F},t} \qquad \text{and} \qquad X_t^*(f) = \frac{1}{1-n}\left(\frac{P^*_{\mathcal{F},t}(f)}{P^*_{\mathcal{F},t}}\right)^{-\varepsilon_p} X^*_{\mathcal{F},t}, \end{aligned}$$

where $X_t = \{C_t, I_t\}$ and $X_t^* = \{C_t^*, I_t^*\}$.

The aggregator (5) implies that home and foreign demands for composite home and foreign are given by

$$\begin{aligned} X_{\mathcal{H},t} &= \omega\left(\frac{P_t}{P_{\mathcal{H},t}}\right) X_t \qquad \text{and} \qquad X^*_{\mathcal{H},t} = \omega^*\left(\frac{P^*_t}{P^*_{\mathcal{H},t}}\right) X^*_t, \\ X_{\mathcal{F},t} &= (1-\omega)\left(\frac{P_t}{P_{\mathcal{F},t}}\right) X_t \qquad \text{and} \qquad X^*_{\mathcal{F},t} = (1-\omega^*)\left(\frac{P^*_t}{P^*_{\mathcal{F},t}}\right) X^*_t. \end{aligned}$$

Then, aggregate outputs in home and foreign goods are

$$Y_t = \omega(\mathcal{T}_t)^{1-\omega}(C_t + I_t) + \frac{1-n}{n}\omega^*(\mathcal{T}_t)^{1-\omega^*}(C_t^* + I_t^*) + G_t + A_t + \eta V_t, \tag{32}$$

$$Y_t^* = (1-\omega)(\mathcal{T}_t)^{-\omega}\frac{n}{1-n}(C_t + I_t) + (1-\omega^*)(\mathcal{T}_t)^{-\omega^*}(C_t^* + I_t^*) + G_t^* + A_t^* + \eta^* V_t^*. \tag{33}$$

1.5 Fiscal and monetary policy

We close the model by specifying the governments and monetary authorities' behaviors. Governments spending (G_t and G_t^*) are exogenous. Governments generate revenue from lump sum taxation and bonds creation and they pay unemployment benefits. Since we do not consider distortions taxes, the two governments face the following budget constraints

$$\begin{aligned} G_t &= T_t + \frac{B_{t+1}/(1+R_t) - B_t}{P_t} - (1-N_t)\Theta, \\ G_t^* &= T_t^* + \frac{B^*_{t+1}/(1+R_t) - B_t^*}{P_t^*} - (1-N_t^*)\Theta^*. \end{aligned}$$

In addition, we assume that the common monetary authorities follow a standard Taylor rule of the form

$$\left(\frac{1+R_t}{1+\bar{R}}\right) = \left(\frac{1+R_{t-1}}{1+\bar{R}}\right)^{\psi_R} (\tilde{\pi}_t)^{\psi_\pi(1-\psi_R)} (\tilde{Y}_t)^{\psi_y(1-\psi_R)}.$$

where $\tilde{\pi}_t = (\pi_t)^n (\pi_t^*)^{1-n}$ denotes the union-wide inflation (*i.e.* the weighted deviations of home and foreign CPI inflations from their steady-state values, normalized to one) and $\tilde{Y}_t = (Y_t/Y_t^p)^n (Y_t^*/Y_t^{*,p})^{1-n}$ is the union's output gap (*i.e.* the weighted deviations of home and foreign outputs to their potential level, defined as the level of output that occurred when prices are flexible).

2 Model Calibration

The model is calibrated for the euro area at a quarterly frequency. The parameter values are based on some key stylized facts and some consistent findings in the literature. We assume that the monetary union consists of two countries which only differ in their labor market characteristics. Therefore, we calibrate the home and foreign labor market parameters with respect to different specifications, based on empirical statistics. In doing so, we seek to highlight whether heterogeneity among labor markets in a monetary union is costly when one of the euro area members is aimed at reducing its unemployment rate.

2.1 Non country-specific parameters

In order to investigate the effects of labor market heterogeneity, we assume equal size between the two countries ($n = n^* = 0.5$) and all parameters – except those linked to the labor market – are calibrated in a symmetric way, replicating the euro area as a whole.

Preferences. We set the discount factor $\beta = 0.99$, which gives an annual steady state real interest rate equal to 4%. We assign values for the intertemporal elasticity of substitution ($\sigma_c = 0.8$), the elasticity of labor disutility ($\sigma_h = 0.45$), and the consumption habit parameter ($b = 0.7$) similar to those estimated by Sahuc and Smets (2008). The elasticity of substitution between differentiated goods ε_p is set equal to 6, corresponding to a markup $\mu_p = 1.2$, as usual in the literature (Rabanal and Rubio-Ramírez, 2008). Finally, the home bias parameter ω, representing the share of home goods on total consumption is set to 0.8 (so $\omega^* = 0.2$).[15]

Production. The share of government spending in the GDP is equal to 21% and the share of consumption in GDP is about 53%. The rate of capital depreciation (δ) is set to 2.5%. The capital share parameter (ϕ) is set to 0.35. The capital adjustment cost parameter ϖ is set to 10.

The degree of price rigidity α_p is set equal to 0.7 implying an average duration of price contracts of less than one year (Dhyne *et al.*, 2006). In addition, the price indexation parameter γ_p is set equal to 0.5, a conventional value in the euro area DSGE literature.

Monetary policy. The reaction function of the monetary authority is assumed to be an inertial Taylor rule with the usual parameter values (Clarida *et al.*, 1998): $\psi_R = 0.85, \psi_\pi = 1.5$ and $\psi_y = 0.125$.

[15] This value is usual in the literature and sensitivity exercises are made below.

Table 1. Unemployment rate

	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	8.5	6.9	6.6	7.5	8.2	8.4	8.4	8.2
Germany	7.9	7.2	7.4	8.2	9.0	9.5	9.4	8.4
Greece	12.0	11.2	10.7	10.3	9.7	10.5	9.8	8.9
Spain	12.5	11.1	10.3	11.1	11.1	10.6	9.2	8.5
France	10.5	9.1	8.4	8.7	9.5	9.6	9.7	9.5
Ireland	5.7	4.2	4.0	4.5	4.7	4.5	4.3	4.4
Italy	10.9	10.1	9.1	8.6	8.4	8.0	7.7	6.8
Luxembourg	2.4	2.3	2.0	2.7	3.7	5.1	4.5	4.7
Netherlands	3.2	2.8	2.2	2.8	3.7	4.6	4.7	3.9
Austria	3.9	3.6	3.6	4.2	4.3	4.8	5.2	4.7
Portugal	4.5	4.0	4.0	5.0	6.3	6.7	7.6	7.7
Finland	10.2	9.8	9.1	9.1	9.0	8.8	8.4	7.7
Euro Area	9.1	8.2	7.8	8.2	8.7	8.8	8.6	7.9

Sources: Eurostat.

2.2 Country-specific parameters

There is a great heterogeneity among the euro area countries concerning the properties of the labor market. Indeed, we can consider three groups of countries with respect to their level of the unemployment rate (Table 1): *(i)* the countries that have a low unemployment rate (Ireland, Luxembourg, Netherlands and Austria), *(ii)* the countries closer to the euro area's rate (Belgium, Italy, Portugal and Finland), and *(iii)* those having a high unemployment rate (Germany, Greece, Spain and France). In addition, Tables 2a and 2b highlight that the unemployment and vacancy durations also vary according to the countries.

For instance, the short-term unemployment rate is high in the Netherlands and to a lesser extent in France whereas the share of long-term unemployment rate is very high in Italy.[16] Consequently, we calibrate the home and foreign labor market parameters in our model so as to reproduce this heterogeneity observed in the euro area. Precisely, we select one country in each group mentioned above (Netherlands, Italy and France) and we examine different combinations of the labor market properties of such countries. As we will see below, each of these countries well depicts a specific degree of frictions in the euro area labor market. In addition, this strategy is aimed at calibrating our theoretical labor market so as to recreate, as precisely as possible, the differences inside the euro area labor market.

[16] The short-term unemployment rate is defined as unemployment with a duration of less than six months.

Table 2a. Vacancy duration (2000) - Share in %

	Hard-to-fill (more than 6 months)
Belgium	10
Germany	8
Netherlands	35
Austria	12
Portugal	15
Finland	47

Sources: ECB (2002).

Table 2b. Unemployment duration (2000) - Share in %

	Short-term (less than 6 months)	Between 6 months and 1 year	Long-term (more than 1 year)
Belgium	28.2	15.5	56.3
Germany	32.4	16.1	51.5
Greece	26.5	17.1	56.4
Spain	37.8	19.7	42.4
France	43.6	16.8	39.6
Ireland	43.1	20.0	36.6
Italy	22.4	16.3	61.3
Luxembourg	56.0	18.8	25.3
Netherlands	53.5	13.8	32.7
Austria	56.2	15.4	28.4
Portugal	40.0	17.1	42.9
Finland	58.9	16.5	24.6
Euro Area	35.3	17.0	47.7

Sources: ECB (2002).

To this end, we consider three specifications for the monetary union. In the first specification (**S0**), we assume that the monetary union consists of two identical countries ($\mathcal{H}$ and $\mathcal{F}$) with labor market properties like those of France. Therefore, the two labor markets in the monetary union are symmetric and relatively rigid. Indeed, although the unemployment rate is about 10.5%, the unemployment and vacancy durations are not strongly extended (about less than 6 months and 3 months, respectively).[17] In a second specification (**S1**), we assume that the currency union consists of two countries having similar unemployment rate (about 10.5%), but differing on the other labor market characteristics. This would correspond to a pattern with France ($\mathcal{H}$) and Italy ($\mathcal{F}$), the latter having an extender unemployment duration than the former (more than one year). This choice is motivated by the interesting observation that France and Italy have the same unemployment rate in 1999 but the rate of Italy decreases until 2006 whereas the rate of France stays at a high level (although volatile during the period). In the last specification (**S2**), the monetary union consists of two countries differing strongly in their labor market characteristics. Precisely, the first country representing by France ($\mathcal{H}$) is characterized by a quite rigid labor market compared with the second country, representing by the Netherlands ($\mathcal{F}$). Indeed, in the foreign country, the unemployment rate is about 3.2% in 1999, the unemployment duration is about less than 6 months and the vacancy duration is about 6 months.

Now, we introduce the calibration of all the labor market parameters according to each specification (*cf.* Table 3).

Labor market aggregates. We assume that in each country, households spend about one third of their time to work ($\bar{H} = \bar{H}^* = 0.30$). In addition, the steady state value of the unemployment rate depends on the specification. In **S0** and **S1**, we assume that the home and foreign unemployment rates are around 10.5% ($\bar{N} = \bar{N}^* \simeq 0.895$). In **S2**, we assume that the foreign country has a more flexible labor market so that its unemployment rate is about 3.2% ($\bar{N}^* = 0.968$; $\bar{N} = 0.895$).

Durations. The unemployment and vacancy durations refer to trading externalities meaning that they indicate the difficulty of finding a worker (or a job). Therefore, the steady-state values of probabilities τ_t and ϱ_t can easily be viewed as indicators of the degrees of friction in the labor market. Consequently, we vary these degrees in the two countries according to the specification. In **S0**, we assume that the monetary union consists of two identical countries (France) with an average unemployment duration of 6 months ($\bar{\varrho} = \bar{\varrho}^* = 0.50$) and an average vacancy duration of about 3 months ($\bar{\tau} = \bar{\tau}^* = 0.95$).[18] This corresponds to an intermediate calibration between a purely rigid labor market and a purely flexible one. In **S1**, we assume that the home country (France) corresponds to a relatively rigid labor market as previously ($\bar{\varrho} = 0.50$ and $\bar{\tau} = 0.95$) whereas the foreign country

[17] This calibration strategy is based on statistics given in Tables 1, 2a and 2b. We calibrate our structural parameters by exploiting these statistics on the period 1999-2000. The choice of the period results from the availability of all the data that we need. In addition, focusing on this period is interesting for our analysis since the unemployment rates in France and Italy were very similar in 1999 (Table 1), whereas some of their labor market properties (i.e. unemployment duration and unemployment benefits) differ significantly.

[18] Since vacancy duration statistics are not available for France and Italy in Table 2a, we consider that the probability of filling a vacancy in these countries is quite high as in Germany, Belgium, Austria or Portugal. Table 2a also shows that this probability is small in the Netherlands.

(Italy) features a more rigid labor market. Indeed, its unemployment duration is of 12 months and its vacancy duration is about 3 months ($\bar{\varrho}^* = 0.25$ and $\bar{\tau}^* = 0.95$). Finally, the monetary union in **S2** consists of a relatively rigid home labor market ($\bar{\varrho} = 0.50$ and $\bar{\tau} = 0.95$) and a flexible foreign labor market (Netherlands). Therefore, the foreign unemployment duration is about 3 months and the vacancy duration is about 6 months ($\bar{\varrho}^* = 0.95$ and $\bar{\tau}^* = 0.50$).

Table 3. Labor market calibration

Parameter	Specification					
	S0		**S1**		**S2**	
	$\mathcal{H}$	$\mathcal{F}$	$\mathcal{H}$	$\mathcal{F}$	$\mathcal{H}$	$\mathcal{F}$
$\bar{H}$	0.300	0.300	0.300	0.300	0.300	0.300
$\bar{N}$	0.895	0.895	0.895	0.891	0.895	0.968
$\bar{\varrho}$	0.500	0.500	0.500	0.250	0.500	0.950
$\bar{\tau}$	0.950	0.950	0.950	0.950	0.950	0.500
s	0.059	0.059	0.059	0.030	0.059	0.031
ξ	0.584	0.584	0.584	0.617	0.584	0.301
ϑ	0.584	0.584	0.584	0.617	0.584	0.301
$\Theta/\bar{W}$	0.750	0.750	0.750	0.540	0.750	0.740
$\eta\bar{V}/\bar{Y}$	0.025	0.025	0.025	0.025	0.025	0.025
α_w	0.600	0.600	0.600	0.600	0.600	0.600

Note: **S0**: The home and foreign labor markets are relatively rigid. **S1**: The home labor market is relatively rigid and the foreign one is more rigid. **S2**: The home labor market is relatively rigid and the foreign one is more flexible.

Destruction rate. The job destruction rate s is deduced from the previous calibrated parameters for each specification.[19] The probability that a worker moves from employment to unemployment is about 5.87% for the two countries in **S0**. It is about 5.87% (resp. 5.87%) for the home country and 3.06% (resp. 3.14%) for the foreign country in **S1** (resp. **S2**).

Bargaining strength. The relative bargaining power of households ξ is also determined by the model's steady state and it depends on the specification. In **S0**, we obtain that $\xi = \xi^* = 0.58$. This value is consistent with Petrongolo and Pissarides (2001). In **S1**, this parameter is set to $\xi = 0.58$ and $\xi^* = 0.61$ in the home and the foreign country, respectively. Finally, in **S2**, we obtain $\xi = 0.58$ and $\xi^* = 0.30$. The lower household's bargaining power in the foreign country results from its high labor market tightness. In addition, we set $\xi = \vartheta$ and $\xi^* = \vartheta^*$.

[19] Indeed, we can deduce s from the equality $s = \bar{\varrho}\bar{U}/(1-\bar{U})$.

Costs and benefits. The unemployment benefits Θ are calibrated in each specification according to some empirical statistics. Precisely, the net replacement rate (in percentage of net earnings in work) is about 75% in France, 54% in Italy and 74% in the Netherlands.[20] In addition, aggregate expenditures on search activity ($\eta \bar{V}/\bar{Y}$) are fixed at 2.5% in each specification for each country.[21]

Wage rigidity. The degree of wage inertia α_w is set to 0.6, as proposed by Faia (2008) in each specification for each country. We will proceed to sensitivity exercises with respect to the calibration of this parameter.

3 The welfare consequences of heterogeneous labor markets

Countries participating in a monetary union are intimately connected by a common monetary policy. Therefore, structural reforms on the labor market directed by a national government can spill over onto a foreign country through the interest rate channel and the trade sector. In addition, the presence of heterogeneity among the labor markets may modify the welfare implications for each country of directing reforms. Our model is clearly not designed to discuss the labor markets' institutional configuration neither the degree of regulation. We rather seek to investigate how labor market reforms in a particular country affect the welfare of the countries into the monetary union.

Precisely, the matching model described above allows us to analyze three transmission mechanisms through which labor market reforms can act: *(i)* a change in the separation process (s); *(ii)* a change in the matching technology ($\tilde{m}$); and *(iii)* a change in the household's bargaining power (ξ). We conduct a simple exercise to study the consequences of a structural reform on the labor market. We make a permanent increase in these key parameters at time 1 in order to reduce the home unemployment rate from 10.5% to 7.9% (the rate reached by the euro area in 2006) and we compute the welfare implication of such a modification. There are many reasons for considering a reduction in matching frictions (through s and $\tilde{m}$). For instance, this could reflect a stabilization of the economy, implying a reduction in the share of time-limited contracts relatively to the number of permanent contracts. This also could be due to an improvement of the services offered by employment agencies. In addition, the reduction in the household's bargaining strength could result from a smaller weight of the trade unions in the bargaining process. We then study the welfare implications of these labor market reforms for each member of the union under different specifications of heterogeneity (**S0**, **S1** and **S2**).

3.1 Measuring welfare gains

As the model provides a fully micro-founded utility criterion, we build on a welfare analysis. In each country $j \in \{\mathcal{H}, \mathcal{F}\}$, we define the welfare associated with the time-invariant stochastic allocation

[20] Sources: Nickell *et al.* (2005) and OECD (2006).

[21] This value is a compromise between the value of 1% reported by Andolfatto (1996) and the 5% reported by Krause and Lubik (2007a).

conditional on the initial steady state ($init$) of the economy in period 0 as

$$\mathcal{W}_{j,0}^{init} = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\sigma_c}{\sigma_c - 1} (C_{j,t}^{init} - bC_{j,t-1}^{init})^{\frac{\sigma_c - 1}{\sigma_c}} - \upsilon N_{j,t}^{init} \left(\frac{\sigma_h}{\sigma_h + 1} \left(H_{j,t}^{init} \right)^{\frac{\sigma_h + 1}{\sigma_h}} \right) \right]$$

where $C_{j,t}^{init}, N_{j,t}^{init}$ and $H_{j,t}^{init}$ denote contingent plans for consumption, employment and individual hours under the initial steady-state. Similarly, we define the conditional welfare associated with a new steady state ($final$) as

$$\mathcal{W}_{j,0}^{final} = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\sigma_c}{\sigma_c - 1} (C_{j,t}^{final} - bC_{j,t-1}^{final})^{\frac{\sigma_c - 1}{\sigma_c}} - \upsilon N_{j,t}^{final} \left(\frac{\sigma_h}{\sigma_h + 1} \left(H_{j,t}^{final} \right)^{\frac{\sigma_h + 1}{\sigma_h}} \right) \right].$$

Like Lucas (1987), we express the welfare gains to a new steady state in readily interpretable economic terms: The gain to the new steady state is given by the fraction of consumption stream an individual should be given in order to compensate the fact that she has to switch from a initial steady state to a new one. In noting

$$\mathcal{O}_{j,0}^{init} = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\upsilon N_t^{init} \left(\frac{\sigma_h}{\sigma_h + 1} \left(H_t^{init} \right)^{\frac{\sigma_h + 1}{\sigma_h}} \right) \right],$$

we measure the welfare gain in percentage points, $\text{Gain}_j = \lambda_j \times 100$, by solving for λ_j the following equation

$$\mathcal{W}_{j,0}^{final} = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\sigma_c}{\sigma_c - 1} (C_{j,t}^{init} - bC_{j,t-1}^{init})^{\frac{\sigma_c - 1}{\sigma_c}} (1 + \lambda_j)^{\frac{\sigma_c - 1}{\sigma_c}} \right] - \mathcal{O}_{j,0}^{init},$$

which gives

$$\lambda_j = \left[\frac{\mathcal{W}_{j,0}^{final} + \mathcal{O}_{j,0}^{init}}{\mathcal{W}_{j,0}^{init} + \mathcal{O}_{j,0}^{init}} \right]^{\frac{\sigma_c}{\sigma_c - 1}} - 1.$$

3.2 Impacts of labor market reforms

We now clarify the incentives for unilateral structural reforms, leading changes in a structural parameter in the home country but leaving those in the foreign one unchanged. Assuming that the home labor market parameters $(s, \tilde{m}, \xi)$ can be affected through various structural policies, we seek to determine the direction in which a country has an incentive to direct its reforms, when the social planner aims at maximizing the social welfare. In particular, we assume that the government in the domestic country wants to reduce its steady-state unemployment rate from 10.5% to 7.9% whereas the foreign labor market is not reformed.[22]

3.2.1 Impact of reforms under different specifications

Table 4 presents the welfare gains for each country of changing one of the three home labor market parameters $(s, \tilde{m}, \xi)$. In each specification, the home country (which directs the structural reform)

[22] Technically, we compute the transition path of variables by making deterministic simulations over 500 periods. One of the structural parameters in $\{s, \tilde{m}, \xi\}$ is shocked so that $\bar{N}^{init} = 0.8950$ and $\bar{N}^{final} = 0.9211$, for each specification.

corresponds to the one with a relatively high degree of frictions on its labor market. Therefore, the three specifications (**S0**, **S1**, **S2**) differ in the degree of frictions on the foreign labor market.[23]

Specification S0 We first discuss the impact of home labor market reforms when the two countries are symmetric and their labor markets are relatively rigid. In the first line of Table 4, we assume that the job destruction rate (s) decreases at time 1 in order to reach a home unemployment rate of 7.9%. Since fewer jobs need to be rematched, home and foreign countries benefit from a welfare improvement. In the first block-column (Table 4), we show that the aggregate welfare increases by 3.22% in the domestic country and 1.49% in the foreign one. To gauge these welfare results more concretely, we note that European personal consumption expenditures were about 15300€ per person in 2006; thus this would permanently increase welfare by about 493€ per person and per period in the home country and 228€ in the foreign country.

In the second line of specification **S0** (Table 4), the decrease in the home unemployment rate from 10.5% to 7.9% results from an increase in the matching efficiency (given by $\tilde{m}$). We obtain similar results than previously. Precisely, reducing the matching frictions by increasing the flow out of employment is beneficial for both countries in specification **S0**. The welfare gain amounts to 3.21% in the home country and 1.48% in the foreign one. Therefore, the permanent increase in welfare would be of 491€ per person in the home country and 226€ per person in the foreign country. Our model suggests that the welfare gain is slightly larger when the new unemployment rate is reached by decreasing the job separation rate rather than by increasing the efficiency of the labor match.

Table 4. Welfare gains (in %) of labor market reforms

Instrument	Specification					
	S0		**S1**		**S2**	
	$\mathcal{H}$	$\mathcal{F}$	$\mathcal{H}$	$\mathcal{F}$	$\mathcal{H}$	$\mathcal{F}$
s	3.2228	1.4855	3.2249	1.0892	3.2252	9.1020
$\tilde{m}$	3.2061	1.4812	3.2082	1.0849	3.2085	9.0975
ξ	-1.3299	0.0273	-1.3249	-0.3634	-1.3298	7.5078
Θ	-0.4054	0.1083	-0.4211	-0.2823	-0.4052	7.5964

Note: **S0**: The home and foreign labor markets are relatively rigid. **S1**: the home labor market is relatively rigid and the foreign one is more rigid. **S2**: the home labor market is relatively rigid and the foreign one is more flexible.

[23] The welfare gains of changing an instrument cannot be compared between the specification. Indeed, the initial steady state in the model varies according to the degree of frictions in the foreign country. However, this welfare gain of changing an instrument can be compared within each specification.

Finally, in the third line of specification **S0** (Table 4), we reach a domestic unemployment rate of 7.9% by reducing the households' bargaining strength (ξ). We then obtain that this reform is not advantageous to the home country since it suffers from welfare losses of about 1.33%. On the contrary, the foreign is not sensitive to this kind of reform since the welfare gains are equal to 0.03%. Therefore, the permanent decrease in welfare would be of 203€ per person in the home country and the welfare gains would reach 5€ per person in the foreign one.

Specification S1 The second block-column (Table 4) indicates the welfare gains of labor market reforms when the monetary union consists of a foreign labor market more rigid than the home one. Concerning the welfare implications of moving s and $\tilde{m}$, we obtain similar qualitative results than in the previous specification. Precisely, reducing the matching frictions in the home country (by making matching more effective or by reducing the separation rate) implies higher welfare gains in the home country than in the foreign one. However, it appears that a reduction in the household's bargaining strength ξ becomes costly in terms of welfare for both countries. Precisely, the permanent decrease in welfare would be of 203€ per person in the home country and 56€ per person in the foreign country. Therefore, as it has been assumed in specification **S2**, extending the foreign unemployment duration ($\bar{\tau}^*$) and reducing its unemployment benefits (Θ^*) implies that the welfare implications of changing ξ becomes negatives for the foreign country.

Specification S2 The last block-column (Table 4) indicates the welfare gains of reforming the home labor market when the monetary union consists of a foreign labor market less frictional than the home one. It appears that the foreign country benefits more than the home country from the home labor market reforms. Precisely, following a reform directed in the home country, the less frictional the foreign labor market, the higher its welfare gains. The welfare gains are about 9% in the foreign country when the matching frictions in the home country are reduced. In addition, reducing the household's bargaining power in the home country results in a reduction in the home welfare (as previously) and a welfare improvement in the foreign country.

Summary

Result 1 Conditionally to our modelling strategy, the largest total (and individual) welfare gain is obtained when the new unemployment rate is reached by decreasing the job separation rate rather than by increasing the efficiency of the labor match or the bargaining power.

Result 2 The euro area as a whole clearly benefits from more flexible labor market at domestic and foreign sides (total welfare is always positive).

3.2.2 Reforms on unemployment benefits

Labor market reforms could also act though a change in the home unemployment benefits (denoted by Θ). Indeed, we could assume that the national government seeks to decrease the unemployment rate through a reduction in the subsidies paid to the unemployed. Then, we consider a permanent decrease in parameter Θ, so as to reach a new steady state unemployment rate of 9.1% in each configuration.[24] The welfare gains implied by this kind of reform are given in the last line of Table 4. We show that the results are similar to the one obtained when the household's bargaining power is reduced. Precisely, the reform is not welfare-enhancing for the home country whereas the foreign country benefits to this modification if its labor market is flexible. This result is not surprising since the unemployment benefits affect directly the real wage (like the household bargaining power). A decrease in Θ generates a reduction in real wages as benefits determine the worker's threat point during the wage bargaining process. Therefore, the household bargaining power and the unemployment benefits parameters have the same welfare implications in this model.

3.2.3 What can explain the results? A transition paths investigation

In the last sub-section, we showed that the welfare implications in the foreign country change according to its degree of labor market frictions. Precisely, the less frictional the foreign labor market (in comparison with the home one), the higher the welfare gains of directing a structural reform in the home labor market. Now, we seek to understand the transmission mechanisms of changing home labor market parameters. Figure 1 plots the transition dynamics of key macroeconomic variables following a modification of the value of s, $\tilde{m}$ and ξ in specification **S0**.[25] The solid lines correspond to a reduction in the job destruction rate (s). The lines with diamonds correspond to an increase in the matching efficiency ($\tilde{m}$). Finally, the dashed lines correspond to a reduction in the household's bargaining power (ξ).

Reform on the matching frictions (s and $\tilde{m}$) The figure shows that the transition paths of the variables are very similar when reforms are directed through s or $\tilde{m}$. This explains why welfare gains are quite similar after these two reforms. Decreasing the separation rate (s) or increasing the efficiency of matching ($\tilde{m}$) reduces frictions emanating from the search process, implying a reduction in the home unemployment rate. A stronger regulation of employment destructions implies a decrease in the unemployment duration. Since the job duration increases, the expected firms' profitability of a job rises. However, this effect is compensated by the fact that the recruitments are more costly since flows of unemployed person in the home labor market decrease at the new steady-state. Therefore, a reduction in the steady-state of the job destruction rate implies that the number of posted vacancies and the unemployment rate decrease. The labor market tightness rises since the reduction in the

[24] It is not feasible to reach an unemployment rate of 7.9% in changing the unemployment benefits Θ (this mechanism by itself is not sufficient in this model). Then, we choose to reach a less ambitious new unemployment rate of 9.1%.

[25] The discussion about the transition paths in specifications **S1** and **S2** is made below.

steady-state unemployment rate is higher than the reduction in the steady-state vacancies. However, this reduction is compensated by a drop in hours worked, implying that real wage rises. This change in the labor market structure results in an increase in the steady-state values of consumption spending and production and a small decline in capital at short term (due to the substitution between labor and capital) supported with a rise in the capital utilization rate. Consequently, real marginal costs slightly rise during the first periods. This implies that home CPI inflation increases in the very short run before to being negative at the new steady-state, probably because the dynamics of the real marginal cost is driven by the response of hours worked.

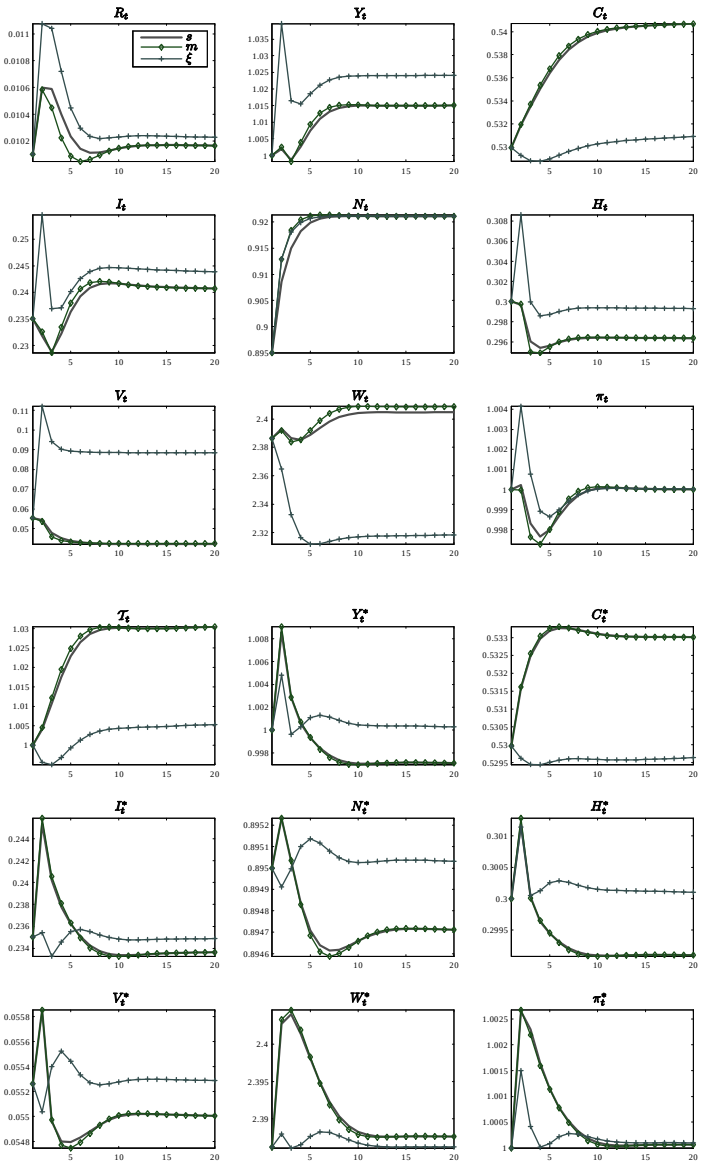
The effects of labor market reforms in the home country spill over onto the foreign country. Indeed, the decrease in home inflation combined with the rise in terms of trade implies an increase in foreign inflation in the short-run of the transition period and a higher new steady-state value of consumption. This is combined with a smaller new steady-state value of total hours (at intensive and extensive margins). Therefore, the foreign country benefits from this kind of home labor market reform.

Ameliorating the efficiency of the matching process implies the same dynamics for all macroeconomics variables. Although the initial mechanism is different (an increase in the number of successful matches in the home labor market), it implies a variation of the labor market tightness in the same direction. The number of posted vacancies and the unemployment rate decrease, due to the presence of congestion effects which make firms' expectations about successful matches less optimistic. These congestion effects imply a fast drop in the home labor market tightness.

In the two cases, the overall improvement in the labor market structure results in an slightly higher steady-state level of consumption spending and production. Therefore, higher consumption and slightly lower hours worked are sufficient to ensure welfare improvement in the home country.

Reform on the household's bargaining strength (ξ) A decrease in the household's bargaining power implies quite different transition paths of the key variables. Such a modification makes a job less profitable. During the wage determination process, domestic households obtain a smaller share of the surplus and domestic firms profit more to the openness of new jobs. The rise in the profitability is naturally expected by firms which post immediately more jobs (vacancies increase). The lower unemployment steady state and the positive effect on the effort of employment's creation lead to a wage moderation (real wages converge toward a smaller steady-state value). In the short-run, households supply more labor along the intensive and extensive margins, and consumption is negative. In the long-run, the higher steady state level of employment is combined with a slightly smaller (resp. higher) steady-state level of hours worked (resp. consumption). However, the harmful transition period implies that the decrease in the household's bargaining power inflicts welfare cost on the home country.

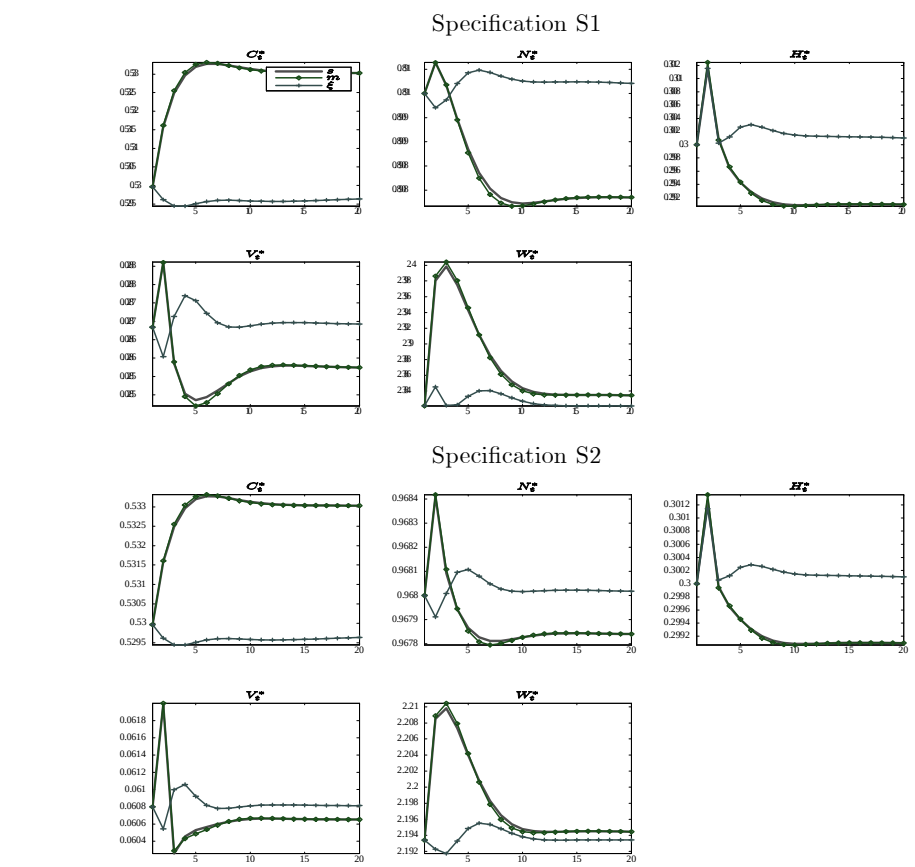
Figure 1. Transition dynamics of macroeconomics variables in specification S0 after a change in s, $\tilde{m}$, ξ



This change in the home economy has also spillover effects onto the foreign one. The simulated transition path of the terms of trade is less volatile than in the case of a change in s or $\tilde{m}$. Therefore, the foreign variables are less affected by a change in the home household's bargaining power. On the contrary to the reforms on s and $\tilde{m}$, the new steady-state value of the foreign employment is slightly higher than the initial one (as for hours worked). In addition, the foreign households consume less in the new steady state, probably due to the real wage moderation and the decrease in the short-run of the terms of trade. Therefore, this implies a small (or negative) welfare gain in the foreign country.

Reform and the degree of foreign labor market flexibility As shown in Table 4, the welfare implications of home labor market reforms on the foreign country depend on its degree of flexibility. For instance, the welfare gains are higher in the foreign country than in the home one (after a change in s or $\tilde{m}$) as soon as its labor market becomes more flexible. In addition, the foreign country benefits from welfare gains of changing ξ only if its labor market is more flexible than the home one. Figure 2 plots the transition paths of the variables related to the foreign labor market when reforms are directed through s, $\tilde{m}$ or ξ in specifications **S1** and **S2**. It appears that foreign employment, hours worked and vacancies converge more rapidly toward their new steady-state values. Therefore, foreign households and firms capture more rapidly the positive effects of the domestic reform. The reason is that the foreign economy benefits from successful matches without being constraint in the bargaining process by more restrictive labor institutions.

Figure 2. Transition dynamics of foreign macroeconomics variables after a change in s, $\tilde{m}$, ξ



3.3 Sensitivity analysis

This sub-section examines the robustness of our findings to changes in the economic environment in the monetary union.

3.3.1 Monetary policy rule

Although monetary policy is neutral in the long run, we can be interested in its role during the transition period. In other words, can the monetary authorities play an important role during the transition path?

Table 5. Welfare gains (in %) under different monetary policy rules

Instrument	Rule	Specification					
		S0		**S1**		**S2**	
		$\mathcal{H}$	$\mathcal{F}$	$\mathcal{H}$	$\mathcal{F}$	$\mathcal{H}$	$\mathcal{F}$
s	(**R0**)	3.2228	1.4855	3.2249	1.0892	3.2252	9.1020
	(**R1**)	3.2213	1.4835	3.2224	1.0873	3.2237	9.0998
	(**R2**)	3.2244	1.4872	3.2265	1.0909	3.2268	9.1038
	(**R3**)	3.2228	1.4855	3.2249	1.0892	3.2252	9.1020
$\tilde{m}$	(**R0**)	3.2061	1.4812	3.2082	1.0849	3.2085	9.0975
	(**R1**)	3.2049	1.4795	3.2070	1.0833	3.2072	9.0954
	(**R2**)	3.2073	1.4824	3.2094	1.0861	3.2096	9.0986
	(**R3**)	3.2070	1.4824	3.2092	1.0862	3.2095	9.0988
ξ	(**R0**)	-1.3299	0.0273	-1.3249	-0.3634	-1.3298	7.5078
	(**R1**)	-1.3340	0.0231	-1.3340	-0.3675	-1.3340	7.5034
	(**R2**)	-1.3261	0.0306	-1.3260	-0.3601	-1.3260	7.5114
	(**R3**)	-1.3295	0.0276	-1.3293	-0.3630	-1.3288	7.5088

To this end, we check the robustness of the previous findings under different monetary policy rules. We consider four type of rules: (**R0**) is the benchmark monetary policy rule ($\psi_R = 0.85, \psi_\pi = 1.5, \psi_y = 0.125$), (**R1**) is an inflation targeting rule ($\psi_\pi = 1.5, \psi_R = \psi_y = 0$), (**R2**) has a stronger reaction to inflation than in the benchmark rule ($\psi_R = 0.85, \psi_\pi = 3, \psi_y = 0.125$), and (**R3**) denotes the benchmark rule including also the unemployment rate (with the same weight as output gap). This

later rule describes the trade-off between inflation and unemployment gap stabilization faced by many central banks.

As shown in Table 5, there are no significant differences among the monetary policy rules, meaning that the way the monetary authorities conduct their policy slightly influences the amount of the welfare gain. Nevertheless, we can observe that rule (**R2**) is the preferable one in each configuration since it gives the highest welfare gains for the two countries. On the opposite, the worst specification seems to be the pure inflation targeting rule. That means that interest rate smoothing is always welfare enhancing. The reason is that a smoothing behavior allows propagating the stabilization effects of monetary policy. Interestingly, we observe that introducing the unemployment rate in the rule does not ameliorate the welfare, except when $\tilde{m}$ is modified. However, this is not surprising since a variation of $\tilde{m}$ is directly related to the unemployment dynamics through the matching function.

3.3.2 Country size and domestic bias

Our main results have been obtained by assuming that the two countries have the same size. However, in specification **S2**, we calibrated the model so that the home country features a relatively rigid labor market (corresponding to France) and the foreign one features a flexible labor market (corresponding to the Netherlands). Therefore, we focus on this specification **S2** so as to investigate whether the consideration of the non-identical size between these two countries modifies our conclusions.

Table 6 (panel a) indicates the welfare gains of modifying s and ξ with respect to the home country size (n) in specification **S2**. Here again, the steady-state values of our model change with the calibration of n implying that we cannot compare the lines between them. Nevertheless, we show that reducing the size of the foreign country has strong effects on its welfare gains. Indeed, when the home country aims at decreasing its unemployment rate from 10.5% to 7.9%, the foreign country is subject to welfare losses as soon as this rate is lower than the home one. This result means that flexibility of the labor market is not a sufficient condition for the foreign country to benefit from the home structural reforms: having the same size is also required.

So as to complete our sensitivity analysis, we indicate the welfare gains of modifying s and ξ with respect to the calibrated value of the home bias ω (Table 6, panel b). As previously, we cannot compare the lines between them due to the modification of the model's steady state. However, we show that our conclusions are robust to the calibrated value of this parameter.

Table 6. Welfare gains (in %) under different configurations

Instrument		Specification	
		S2	
		$\mathcal{H}$	$\mathcal{F}$
Panel a. Difference in the country size			
s	$n = 0.50$	3.2252	9.1020
	$n = 0.55$	3.1780	-12.4539
	$n = 0.60$	3.1544	-31.7277
ξ	$n = 0.50$	-1.3298	7.5078
	$n = 0.55$	-1.0753	-13.7908
	$n = 0.60$	-0.7735	-32.8482
Panel b. Difference in the home bias			
s	ω= 0.80	3.2252	9.1020
	$\omega = 0.70$	2.5975	9.7701
	$\omega = 0.60$	1.9338	10.4585
ξ	$\omega = 0.80$	-1.3298	7.5078
	$\omega = 0.70$	-1.4317	7.6073
	$\omega = 0.60$	-1.5880	7.7894

3.3.3 Nominal rigidities

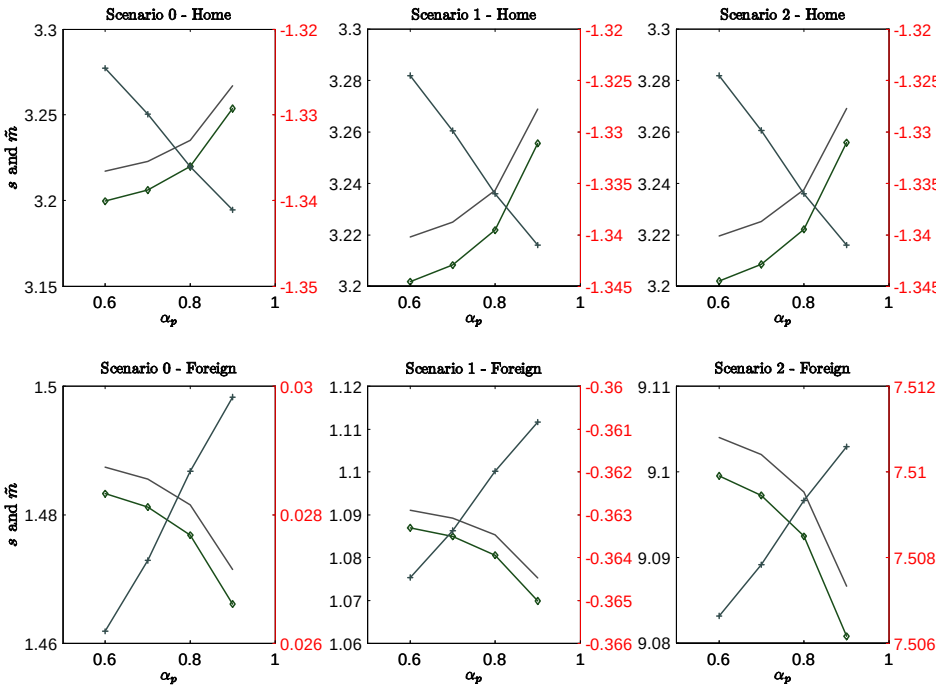
The presence of nominal rigidities in our model implies some deviations of economic activity from its natural level which are potentially costly in terms of welfare. Here, we highlight the impact of these rigidities in our welfare analysis.

Price rigidities The Calvo-price staggering framework is characterized by a price dispersion among producers, meaning that prices are not re-adjusted to their efficient level at each period. Therefore, a lower degree of price rigidity should result in a welfare-enhancing in the two countries. Figure 3 displays the welfare gains of changing a labor market instrument in the home country (s, $\tilde{m}$ and ξ) so as to reduce the home unemployment rate from 10.5% to 7.9%, with respect to the degree of price rigidity (α_p). The solid lines correspond to a reduction in the job destruction rate, s (left scale). The lines with diamonds correspond to an increase in the matching efficiency, $\tilde{m}$ (left scale). Finally, the dashed lines

correspond to a reduction in the household's bargaining power, ξ (right scale).

It clearly appears that the evolution of the welfare gains with respect to the value of α_p is robust to the considered specification. When the household's bargaining power are reduced, the more rigid the home prices, the smaller the home welfare gains. On the contrary, the foreign welfare gains are higher. This result is inverted when the matching frictions are reduced. This means that removing price rigidities is not necessary welfare-enhancing, particularly when these nominal rigidities are combined with a modification in the matching frictions. Precisely, we show that a high degree of price rigidity magnifies the welfare implications of reforming matching frictions in the home country. This result highlights that several frictions (matching frictions, for instance) can offset the negative effect of price rigidities in the economy.

Figure 3. Welfare gains (in %) of changing s, $\tilde{m}$ and ξ in function of the price rigidity



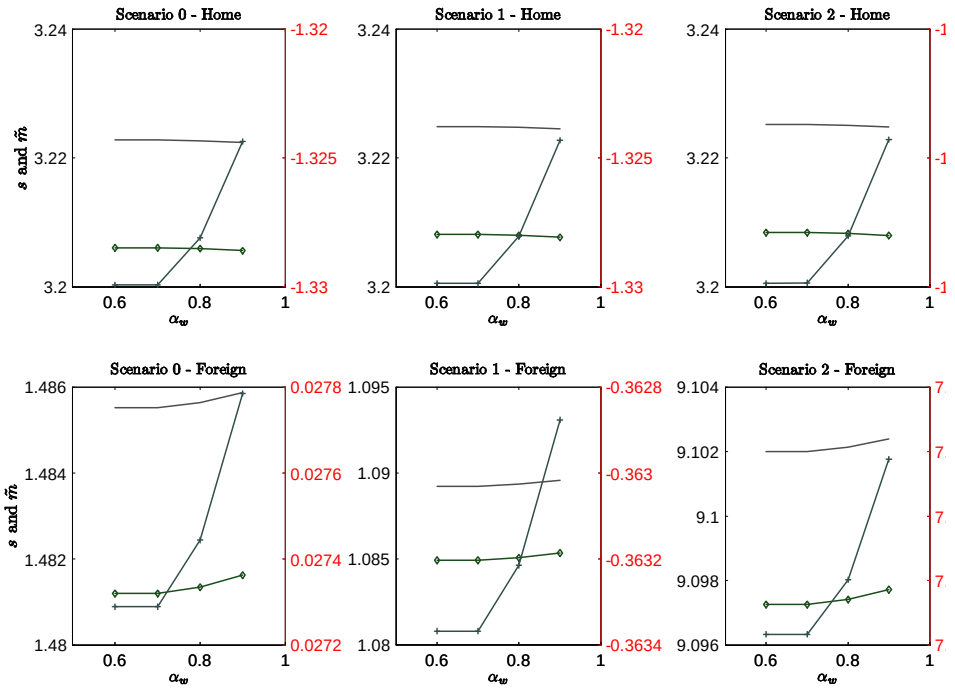
Note: The abscissa corresponds to the degree of price rigidity. The solid lines correspond to the welfare gains of reducing s (left scale). The lines with diamonds correspond to the welfare gains of reducing m (left scale). The dashed lines correspond to the welfare gains of rising the household's bargaining power (right scale).

Wage inertia We introduced inertia in the wage dynamics through the backward-looking social norm assumption. However, we could not easily observe the wage adjustment rate (α_w). Therefore,

we check whether the welfare gains change with the calibration of α_w. Figure 4 displays the welfare gains of changing a labor market instrument in the home country (s, $\tilde{m}$ and ξ) so as to reduce the home unemployment rate to 7.9%, with respect to α_w. The solid lines correspond to a reduction in the job destruction rate s (left scale). The lines with diamonds correspond to an increase in the matching efficiency $\tilde{m}$ (left scale). Finally, the dashed lines correspond to a reduction in the household's bargaining power ξ (right scale).

We show that the welfare gains are not very sensitive to the calibrated value of α_w, whatever the specification (especially when s and $\tilde{m}$ are changed). In addition, we show that the welfare gains slightly change with the value of α_w when the household's bargaining power is reduced. Indeed, the higher the degree of wage inertia, the smaller the welfare losses and the higher the welfare gains for the home and the foreign country, respectively. This result is not surprising since α_w is directly related to the wage determination equation, as well as the household's bargaining power. Consequently, the effects of a reform on ξ are slightly sensitive to the value of the degree of wage inertia.

Figure 4. Welfare gains (in %) of changing s, $\tilde{m}$ and ξ in function of the wage rigidity



Note: The abscissa corresponds to the degree of wage rigidity. The solid lines correspond to the welfare gains of reducing s (left scale). The lines with diamonds correspond to the welfare gains of reducing m (left scale). The dashed lines correspond to the welfare gains of rising the household's bargaining power (right scale).

Conclusion

The bad performance of the euro area labor market influences the well being of both the economy and society. The literature has attempted to incorporate labor market search and matching frictions in closed-economy representations of the area, however, in a single currency union, an additional difficulty due to the heterogeneity of the members appears. In this paper, we studied the role of labor markets heterogeneity in a monetary union and more particularly we investigated what are the welfare gains/costs of labor market reforms for each member of the area. We developed a medium-scale two-country model representing a currency union characterized by price and wage stickiness, real rigidities and labor market frictions.

Assuming that the model's labor market parameters can be affected through various structural policies, we seek to determine the direction in which a country has an incentive to direct its reforms, when the social planner aims at maximizing the social welfare. Precisely, we focus on three parameters related to the labor market structure: the job destruction rate, the scaling parameter in the matching function, and the households' bargaining power. We assume a permanent shock on these structural parameters in order to achieve a lower home unemployment rate and we compute the social welfare gains/costs.

We find that the choice of the instrument to direct a reform (aiming at reducing the home unemployment rate) play a crucial role on the size of the social welfare gain in the union. Especially, the welfare gain is slightly higher by decreasing the job separation rate rather than by increasing the efficiency of the labor match. On the contrary, a decrease in the households' bargaining power leads to mitigate effects on the social welfare. In addition, the effects of a domestic reform on the "foreign welfare" depend on the characteristics of the foreign labor market. More particularly, the more flexible the foreign labor market, the higher the welfare gain. A sensitivity analysis also shows that the way the monetary authorities conduct their policy slightly influences the amount of the welfare gain, whatever the specification. Nevertheless, among different type of interest rate rules, using a rule including a strong reaction to inflation allows to obtain the largest welfare improvement in both home and foreign country. Finally, the size of a country in the monetary union plays an important role on the welfare effects. For example, if the foreign country with a flexible labor market has a small weight in the union, it can obtain a sizeable welfare loss following a domestic reform.

References

[1] Andolfatto D. (1996), "Business Cycles and Labour Market Search", *American Economic Review*, 86, 112-132.

[2] Benigno G. and Benigno P. (2003), "Price Stability in Open Economies", *Review of Economic Studies*, 70, 743–764.

[3] Blanchard O. and Gali J. (2007), "A New Keynesian Model with Unemployment", *Working Paper n°2007/08,* Center for Financial Studies.

[4] Bodart V. de Walque G. Pierrard O. Sneessens H. and Wouters R. (2006), "Nominal Wage Rigidities in a New Keynesian Model with Frictional Unemployment", *Working Paper n°97*, National Bank of Belgium.

[5] Calvo G. (1983), "Staggered Prices in a Utility-Maximizing Framework", *Journal of Monetary Economics*, 12, 383-398.

[6] Chari V. V. Kehoe P. and McGrattan E. (2002), "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?", *Review of Economic Studies*, 69, 533-563.

[7] Chéron A. and Langot F. (2004), "Labor Market Search and Real Business Cycles: Reconciling Nash Bargaining with Real Wage Dynamics", *Review of Economic Dynamics*, 7, 476-493.

[8] Christiano L. Eichenbaum M. and Evans C. (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy", *Journal of Political Economy*, 113, 1-45.

[9] Christoffel K. and Linzert T. (2005), "The Role of Real Rigidity and Labor Market Frictions for Unemployment and Inflation Dynamics", *Working Paper n° 556,* European Central Bank.

[10] Clarida R. Gali J. and Gertler M. (1998), "Monetary Policy Rules in Practice: Some International Evidence", *European Economic Review*, 42, 1033-1067.

[11] Clarida R. Gali J. and Gertler M. (2002), "A Simple Framework for International Monetary Policy Analysis", *Journal of Monetary Economics*, 52, 281-305.

[12] Compolmi A. and Faia E. (2007), "Labor Market Institutions and Inflation Volatility in the Euro Area", *revised version of Working Paper n°619*, European Central Bank.

[13] Corsetti G. and Pesenti P. (2005), "The International Dimension of Optimal Monetary Policy", *Journal of Monetary Economics*, 52, 281—305.

[14] Dellas H. and Tavlas G. (2005), "Wage Rigidity and Monetary Union", *Economic Journal*, 115, 907-927.

[15] Devereux M. and Engel C. (2003), "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility", *Review of Economic Studies*, 70, 765-783.

[16] Dhyne E. Álvarez L. Le Bihan H. Veronese G. Dias D. Hoffman J. Jonker N. Lünnemann P. Rumler F. et Vilmunen J. (2006), "Price Changes in the Euro Area and the United States. Some Facts from Individual Consumer Price Data", *Journal of Economic Perspectives*, 20, 171-192.

[17] ECB (2002), *Labor Market Mismatches in Euro Area Countries*, European Central Bank.

[18] Faia E. (2008), "Optimal Monetary Policy Rules with Labor Market Frictions", forthcoming in *Journal of Economic Dynamics and Control*.

[19] Galí J. and Monacelli T. (2005), "Monetary Policy and Exchange Rate Volatility in a Small Open Economy", *Review of Economic Studies*, 72, 707-734.

[20] Gertler M. and Trigari A. (2006), "Unemployment Fluctuations with Staggered Nash Wage Bargaining", *NBER Working Papers* $n°$12498.

[21] Guichard S. and Laffargue J-P. (2000), "The Wage Curve: The Lessons of an Estimation Over a Panel of Countries", *Working Paper* $n°$2000-21, CEPII.

[22] Hall R. (2005), "Employment Fluctuations with Equilibrium Wage Stickiness", *American Economic Review*, 95, 50-65.

[23] Hughes Hallett A. and Viegi N. (2003), "Labor Market Reform and Effectiveness of Monetary Policy in EMU", *Journal of Economic Integration,* 726-749.

[24] Jondeau E. and Sahuc J-G. (2008), "Optimal Monetary Policy in an Estimated DSGE Model of the Euro Area with Cross-country Heterogeneity", forthcoming in the *International Journal of Central Banking*.

[25] Krause M. and Lubik T. (2007a), "On-the-Job Search and the Cyclical Dynamics of the Labor Market", *Working Paper* $n°$779, European Central Bank.

[26] Krause M. and Lubik T. (2007b), "The (Ir)Relevance of Real Wage Rigidity in the New Keynesian Model with Search Frictions", *Journal of Monetary Economics*, 54, 706-727.

[27] Lucas R. (1987), *Models in Business Cycle*, Basil Blackwell, New York.

[28] Merz M. (1995), "Search in the labor Market and the Real Business Cycle", *Journal of Monetary Economics*, 36, 269-300.

[29] Moyen S. and Sahuc J-G. (2005), "Incorporating Labor Market Frictions into an Optimising-Based Monetary Policy Model", *Economic Modelling*, 22, 159-186.

[30] Nickell, S. Nunziata, L. Ochel, W. 2005. "Unemployment in the OECD since the 1960s. What do we know?", *Economic Journal*, 115, 1-27.

[31] OECD (2006), "OECD Employment Outlook", Benefits and Wages database.

[32] Petrongolo B. and Pissarides C. (2001), "Looking into the Black Box: A Survey of the Matching Function", *Journal of Economic Literature*, 38, 390-431.

[33] Rabanal P. and Rubio-Ramirez J. (2008), "Comparing New Keynesian Models in the Euro Area: A Bayesian Approach", forthcoming in *Spanish Economic Review*.

[34] Sahuc J-G. and Smets F. (2008), "Differences in Interest Rate Policy at the ECB and the Fed: An Investigation with a Medium-Scale DSGE Model", *Journal of Money, Credit, and Banking*, 40, 505-521.

[35] Smets F. and Wouters R. (2002), "Openess, Imperfect Exchange Rate Pass-Through and Monetary Policy", *Journal of Monetary Economics*, 49, 947-981.

[36] Smets F. and Wouters R. (2003), "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area", *Journal of the European Economic Association*, 1, 1123-1175.

[37] Smets F. and Wouters R. (2005), "Comparing Shocks and Frictions in US and Euro Area Business Cycles: A Bayesian DSGE Approach." *Journal of Applied Econometrics*, 20, 161-183.

[38] Thomas C. (2007), "Search and Matching Frictions and Optimal Monetary Policy", *Manuscript,* London School of Economics.

[39] Trigari A. (2005), "Equilibrium Unemployment, Job Flows and Inflation Dynamics", *revised version of Working Paper n°*304, European Central Bank.

[40] Trigari A. (2006), "The Role of Search Frictions and Bargaining for Inflation Dynamics", *Working Paper n°*304, Università Bocconi.

[41] Walsh C. (2005), "Labor Market Search, Sticky Prices, and Interest Rate Policies", *Review of Economic Dynamics*, 8, 829-849.

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