Divergence in Labor Market Institutions and International Business Cycles

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Abstract

The paper investigates the international GDP synchronization within the international real business cycle framework (Backus, Kehoe and Kydland [1992]). It sheds new light on the comovement issue by highlighting the role of cross-country divergence in labor market institutions (LMIs). We first document the empirical link between labor market heterogeneity and GDP comovement in a sample of 15 OECD countries over the recent period. Labor market heterogeneity significantly reduces cross-country GDP correlation. Besides, the effects are non-trivial, as they are found to depend on the design of LMIs. We then investigate this stylized fact within the two-country RBC model with labor-market frictions *à la* Pissarides [1990], that we amend to take into account asymmetric LMIs. The model rationalizes the link between labor market heterogeneity and GDP comovement observed in the data. Our results show that taking into account the design of LMIs among OECD countries improves our understanding of their business cycles comovement.

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1 Introduction

What are the determinants of international business cycles? If the question has long been addressed by international macroeconomics (Mundell [1961]), it has met a substantial renewal in the recent years with the use of new micro-founded theoretical grounds. Rationalizing the underlying mechanisms of international business cycles in a fully micro-founded dynamic general equilibrium model lies at the heart of the International Real Business Cycle (IRBC) literature, starting with Backus, Kehoe and Kydland's [1992] seminal paper. Yet, IRBC models that typically assume flexible prices and wages fail to replicate the strong positive GDP cross-country correlation observed in the data (Baxter [1995], Backus, Kehoe and Kydland [1995]). Hairault's [2002] contribution makes substantial progress on that front by showing that the introduction of labor-market frictions *à la* Pissarides [1990] in a two-country RBC model brings the model closer to the data. Kollmann [2001] introduces money in the IRBC framework and highlights the role of monetary innovations combined to price and wage rigidities in international comovement.

All international business cycle models in the international comovement literature typically retain the assumption of symmetric countries. Yet, this may seem empirically unappealing in view of the remarkable differences that still exist in labor and product markets among OECD countries (OECD [2004]). When one wishes to design a "good" model to account for international business cycles, it seems crucial to take into account the specific institutional environment that affects the propagation of aggregate shocks. Within OECD countries, one striking divergence lies in labor market institutions (LMIs). Simple descriptive statistics illustrate that point. Among a set of 15 OECD countries over the 1973-1998 period, Employment Protection Laws (EPL) indices take values between 0.2 and 1.3 (the maximal value being 2), while tax wedges range from 30% to 70% and unemployment benefit ratios lie within a 5% - 50% interval.[1] Besides, given the influence of labor market regulations on the determination of wages and employment, labor market heterogeneity is likely to substantially affect the dynamics of macroeconomic variables, hence their business cycle synchronization. The paper thus investigates its role in international comovement by including heterogenous LMIs in the two-country RBC model with labor market frictions.

The labor market literature has extensively studied the effects of labor market regulations on economic performances in OECD countries. Studies such as Scarpetta [1996], Belot and Van Ours [2004] or Nickell, Nunziata and Ochel [2005] empirically evaluate the role of LMIs on equilibrium unemployment in OECD countries over the last decades. Based on a panel of 20 OECD countries since 1960, Blanchard and Wolfers [2000] show that the interaction between country-specific aggregate shocks and heterogenous LMIs is crucial to account for the cross-country

[1] These descriptive statistics are based on Nickell's [2006] database on Labor Market Institutions covering 15 OECD countries over the 1973-1998 period.

divergence in employment performances observed in the data. Using data on six OECD countries, Langot and Quintero-Rojas [2008] conclude that taxes have a significant impact on the long run evolution of worked hours, consistently with Prescott's [2004] and Rogerson's [2006] findings. Even though no clear-cut consensus emerges on the key dimensions in LMIs that affect employment performances, all related papers acknowledge a critical role of labor market regulations on the topic. Besides, empirical evidence suggest that heterogeneity in labor market regulations matters as well.

The originality of our paper lies in investigating the role of labor market heterogeneity on international GDP comovement. One may argue that the answer is rather trivial. With symmetric LMIs, countries react similarly to exogenous shocks, resulting in a high cross-country GDP correlation *ceteris paribus*. In contrast, asymmetric LMIs are likely to induce divergent output dynamics across countries, thereby lowering international comovement. Intuition suggests that heterogenous LMIs reduce GDP comovement. Yet, if true, this reasoning only applies to common shocks. The effects of labor market heterogeneity on international comovement is less easily predictable in the advent of country-specific shocks. In the paper, we indeed show that divergence in LMIs affects international comovement, but in a non-trivial way. Notably, the level of labor market regulations is found to matter as well.

The role of labor market heterogeneity in international fluctuations has hardly been explored in the international business cycle literature. Campolmi and Faia [2006] and Poilly and Sahuc [2008] are recent notable exceptions. Poilly and Sahuc [2008] focus on the welfare effects of labor markets reforms within a (European) monetary union. Campolmi and Faia [2006] point out that cross-country differences in LMIs are major driving forces behind the inflation differentials observed in Europe. The paper is closer to Campolmi and Faia [2006] since we are interested in assessing the effects of labor market heterogeneity on macroeconomic dynamics. We differ from them along two dimensions. First, we evaluate the role of labor market heterogeneity in international fluctuations of OECD countries, rather than focusing on European countries within a monetary union. Secondly, the paper addresses the question of the determinants of international comovement in macroeconomic aggregates (employment, production), rather than inflation dynamics. This leads us to discard the introduction of the nominal dimension in the model and to stick to a real business cycle framework.

Does labor market heterogeneity matter in explaining business cycle (de)synchronization among OECD countries? If so, through which LMI dimensions? Through which economic mechanisms? We provide an answer to the first two questions by looking at the data. Using data covering a set of 15 OECD countries over the 1973-1998 period, we first calculate the cross-country GDP correlation between all pairs of countries (105 cross-country correlations). We thereby better capture the heterogeneity in business cycle synchronization among OECD countries, rather than considering only comovement with the United-States, as usually done in the literature (Backus, Kehoe and Kydland [1995], Hairault [2002]). We then empirically evaluate the effects of labor market heterogeneity on GDP comovement. First, we obtain that cross-country divergence in LMIs, namely in employment protection laws (EPL), significantly reduces cross-country GDP correlation. Secondly, we get differentiated effects depending on the overall level of EPL. The more stringent the employment protection laws within a country pair, the less synchronized their business cycles. Labor market heterogeneity affects international comovement, in a non-trivial way since the design of LMIs *per se* also matters.

The objective of the paper is then to rationalize the underlying economic mechanisms in a dynamic general equilibrium model. We adopt the international RBC model with labor-market search frictions *à la* PISSARIDES [1990]. Modeling labor-market matching frictions allows to study equilibrium unemployment in a non-Walrasian economy and the role of labor market regulations within this framework. Unlike CAMPOLMI and FAIA [2006] and POILLY and SAHUC [2008], we discard the introduction of money and nominal rigidities. With transparent mechanisms on the good-market side, this framework allows to better identify the specific effects of asymmetries in labor market adjustments due to heterogenous LMIs. Our setting is thus close to HAIRAULT's [2002] model, amended by the introduction of asymmetric LMIs across countries. The model is calibrated on the United-States and France respectively, as these countries capture the differences between the Anglo-Saxon "flexible" labor markets and the more "rigid' ones of continental Europe.

We find that the model rationalizes the empirical effects of labor market heterogeneity on GDP comovement in OECD countries. IRF analysis shows that it affects the international transmission of supply shocks, whether the shocks are common or country-specific. The design of LMIs matters as well. The more rigid labor markets in both countries, the more dampened the responses of macroeconomic aggregates to exogenous shocks. Accordingly, in quantitative terms, the model predicts that asymmetric LMIs reduce the cross-country GDP correlation, as compared to the case when both countries have flexible LMIs. GDP correlation is even lower when both countries feature stringent labor market regulations, consistently with the data. The paper delivers the message, that taking into account the design of LMIs among OECD countries is important if we are willing to explain their business cycle synchronization. This finding may be of particular interest for policy makers, namely in the Euro zone's perspective. It gives support to the view that harmonization of European labor markets can ease the conduct of the European central bank's monetary policy.

The paper proceeds as follows. Section 2 evaluates the empirical role of labor market heterogeneity on GDP comovement, using data covering 15 OECD countries over the 1973-1998 period. In the subsequent sections, we investigate the underlying economic mechanisms within a two-country DSGE model. Section 3 presents the model and Section 4 the calibration of structural parameters. In Sections 5 and 6, we evaluate the model's predictions regarding the link between labor market heterogeneity and international comovement. Section 7 concludes.

2 What are the facts?

To what extent heterogeneity across OECD labor markets affects the extent of their business cycle synchronization? This section presents some stylized facts that evaluate the relationship between both variables.

We capture international business cycle comovement by the cross-country GDP correlation (denoted ρ^y), as standard in the international business cycle literature. We use quarterly data on a sample of 15 OECD countries over the 1973:2-1998:4 period. Cross-country GDP correlation is calculated over the whole period for all country-pairs, after GDP series have been logged and filtered using the Hodrick and Prescott [1997] filter. This gives us 105 cross-country GDP correlations. Details on the countries in the sample and data sources are provided in Appendix A.

To measure the degree of labor market heterogeneity among these countries, we rely on Nickell's [2006] dataset covering LMIs in OECD countries since the early 1960s. Starting from the fact that labor market regulations cover multiple dimensions, this raises the question of which dimensions to consider. We retain those that are usually considered in the labor market literature (Belot and Van Ours [2004] among others), *i.e.* EPL, union coverage, that is the share of employees that are covered by collective agreements intended to capture unions' bargaining power (denoted uc hereafter),[2] unemployment benefit replacement ratio (brr) and tax wedge (tw). The higher the variable, the more stringent labor market regulations. For each LMI dimension and each country pair (i, j) of the sample, we then build a measure of labor market heterogeneity as the absolute value of the cross-country difference of LMI values (considering the mean value of the LMI variable over the period):

$$\text{Diff. in LMI}_{ij} = \mid \text{LMI}_i - \text{LMI}_j \mid \tag{1}$$

with LMI $= EPL$, uc, brr and tw.

We then investigate the empirical link between labor market heterogeneity among OECD countries and their business cycle synchronization. We first estimate the impact of labor market heterogeneity on the cross-country GDP correlation in ordinary least-squares (OLS) regressions. Results are reported in Table 1, columns (A) to (D).

[Insert Table 1 here]

OLS results indicate that difference in the generosity of the unemployment benefit system has no significant effect on the cross-country GDP correlation. In contrast, the coefficients associated with

[2] Nickell's [2006] database also delivers information on union density, that is the share of employees who are union members. Since this variable is also considered as capturing the unions' bargaining power, we have included it in our dataset. Results are very similar to those obtained with union coverage. As this last variable is considered as a better proxy for the unions' bargaining power (Nickell [1997]), and for sake of space saving, we only report here the results with union coverage.

divergence in union coverage, tax wedge and the degree of employment protection are estimated significantly negative.

To convincingly establish the robustness of the link, we need to ensure that the effects on GDP comovement captured by differences in LMIs are not attributable to other observable or unobservable omitted variables. To that aim, we run regression according to the following specification:

$$\rho_{ij}^{y} = \alpha + \beta X_{ij} + \mu_i + \mu_j + \gamma Y_{ij} + \varepsilon_{ij} \tag{2}$$

ε_{ij} is the residual with standard properties (mean equal to 0 and uncorrelated with itself) and α a constant. X_{ij} denotes our measure of divergence in LMIs (in the various dimensions considered). To control for the omitted variable bias, we include country fixed effects (μ_i and μ_j, denoted FE in Table 1). Depending on the specification, the estimated equation may also include a set of observable control variables (Y_{ij}) that are likely to affect international comovement. On this topic, there is no consensus in the literature on the key determinants of international business-cycles comovement (Baxter and Kouparitsas [2005], Darvas, Rose and Szapary [2005], Imbs [2001] among others). Baxter and Kouparitsas [2005] empirically study the robustness of various candidate explanations of GDP comovement (bilateral trade, currency unions, industrial similarity, etc.). While each of them is found to play a significant role in business cycle synchronization, only a few of them remain robust when all variables are included in the regression. However, they find strong support for bilateral trade intensity in explaining GDP comovement. This leads us to retain this dimension as a control variable in the regression.

Based on previous OLS results, we expect β the parameter related to LMI differences to be negative. Besides, when included, we expect γ to be positive, as more bilateral trade is usually found to enhance business cycle comovement (Baxter and Kouparitsas [2005], among others). Regression results are reported in Table 1, columns (E) to (I). Difference in the unemployment benefit ratio is not found to play a significant role in GDP comovement. Differences in union coverage and in tax wedge are also estimated insignificant (columns (E) and (G)). While these two variables were found significant in a simple OLS regression, their role in GDP comovement is not robust to the inclusion of country-pair fixed effects. Only divergence in employment protection is found to be robust in accounting for international GDP (de)synchronization, as its coefficient is estimated significantly negative (column (H)). Besides, this result remains when bilateral trade intensity is included in the regression (column (I)). In that case, bilateral trade is also estimated significant and of expected sign.

Results reported in Table 1 yield the conclusion that labor market heterogeneity among OECD countries matters in business cycle synchronization. If this may occur through various LMI dimensions, difference in employment protection appears to be the most robust channel through which divergence in LMIs reduces GDP comovement.

One may then wonder whether LMIs affect business cycle synchronization in the single dimension of the cross-country heterogeneity, or whether the level *per se* of these regulations also matters. This leads us to investigate the role of the degree of employment protection on GDP comovement. To that aim, we partition the 15 countries of the sample in a "flexible LMI" group and a "rigid LMI" group according to their relative degree of employment protection laws. We retain in the "flexible LMI" group the countries whose average EPL indicator over the period is below the median value of the sample, and in the "rigid LMI" group the countries whose average EPL indicator is superior or equal to the median.[3] We then build 2 dummy variables: *i)* the dummy "Both Rigid in EPL" takes the value 1 if the two countries of the pair (i, j) belong to the "rigid LMI" group, *ii)* the dummy "Both Flexible in EPL" takes the value 1 if the two countries of the pair (i, j) belong to the "flexible LMI" group. The case with Asymmetric EPL (one country of the pair (i, j) belongs to the "flexible LMI" group, while the other belongs to the "rigid LMI" group) then constitutes the reference level in the regression. We can then assess the role of the level of labor market rigidity (or flexibility) of a country pair in their business cycle comovement, as compared to the asymmetric LMI case. Results are reported in Table 2.

[Insert Table 2 here]

For sake of comparison, Table 2, column (A) reports the regression results when considering the role of cross-country divergence in employment protection (Table 1, column (I)). In columns (B) and (C), the reference dummy is the "Asymmetric in EPL" one. As the "rigid LMI" group includes almost exclusively countries that belong to the European Monetary System (EMS) over the period (Sweden being an exception), one may argue that the dummy "Both Rigid in EPL" actually captures this dimension (rather than similarity in (stringent) EPL). To eliminate this potential bias in interpreting the related results, we build a dummy "Both EMS" taking the value 1 if the two countries of the pair belong to the EMS, 0 otherwise.[4] We check the robustness of the results to the inclusion of this dummy in Table 2, column (C).

As reported in Table 2, the coefficient associated to the dummy "Both Rigid in EPL" is estimated significantly negative, whereas the one associated to "Both Flexible in EPL" is significantly positive. These results indicate that the level of LMIs *per se* matters. Two countries with both rigid labor markets are found to have less correlated business cycles as compared to the case where one at least has flexible LMIs. The fact that the two countries have both flexible employment protection laws raises even more their business cycle synchronization, relative to the asymmetric case.

[3]This leads us to identify as the "flexible LMIs" group the following set of countries: Austria, Canada, Denmark, Finland, Japan, United Kingdom and the United States. In the "rigid LMIs" group are the others: Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain and Sweden.

[4]The dummy takes the value 1 for the country pairs made of the following countries: Belgium, France, Germany, Italy, the Netherlands, Portugal and Spain.

Our overall empirical results suggest the following interpretation. First, labor market heterogeneity among OECD countries plays a role in accounting for their business cycle (de)synchronization. In particular, divergence in employment protection laws is found to significantly reduce the cross-country GDP correlation.[5] Secondly, the message conveyed by the data is more subtle, as the design of LMIs also matters. The overall degree of labor market rigidity between countries limits their business cycle synchronization, and having even one country of a pair adopting more flexible employment protection laws raises the magnitude of their GDP comovement.

The objective is now to account for these stylized facts and to rationalize their underlying economic mechanisms, relying for that purpose on a two-country DSGE model. This is done in the next sections.

3 A two-country model with labor market institutions

We develop a two-country dynamic stochastic general equilibrium (DSGE) model. As in Hairault [2002], we introduce labor market frictions in an otherwise perfectly competitive two-goods economy. Each country is assumed to be completely specialized in the production of a single homogenous good. In each country, households consume a basket of Home and Foreign varieties. As in Hairault [2002] and Campolmi and Faia [2006], the labor market features matching frictions *à la* Pissarides [1990]. Wages and hours are assumed to be the result of an efficient Nash-bargaining process between firms and workers, as in Andolfatto [1996], Chéron and Langot [2004] or Hairault [2002] (among others). Performances in employment, hence in output are thus directly affected by LMIs. Such a setting consequently allows to investigate the impact of LMI heterogeneity on international GDP comovement.

3.1 The search process on the labor market

Let N_{it} and V_{it} respectively denote the number of workers and the total number of new jobs made available by firms in country i at the beginning of period t. The law of motion for aggregate employment is defined as:

$$N_{it+1} = (1 - s_i)N_{it} + H_{it} \tag{3}$$

with $0 < s_i < 1$ the exogenous separation rate of job–worker pair in country i, and H_{it} the number of hirings per period, which is determined by a conventional constant returns-to-scale matching technology *à la* Pissarides [1990]:

$$H_{it} = \chi_i V_{it}^{\psi}(1 - N_{it})^{1-\psi} \tag{4}$$

[5] Using a data-panel analysis covering a sample of 20 OECD countries over 1964-2003, Fonseca, Patureau and Sopraseuth [2008] also find evidence that divergence in employment protection matters.

As the population size is normalized to unity, $U_{it} = 1 - N_{it}$ is the measure of the unemployment rate.[6] The parameter $0 < \psi < 1$ measures the bargaining power of firms in the Nash negotiation process. $\chi_i > 0$ is a scale parameter measuring the "efficiency" of the matching function. Due to the time-consuming nature of search on the labor market, a job vacancy can at best become productive only one period after time has slipped by. Defining $\phi_{it} = \frac{H_{it}}{1-N_{it}}$ as the probability to find a job for unemployed workers, the law of motion of employment in country i can be re-written as:

$$N_{it+1} = (1 - s_i)N_{it} + \phi_{it}(1 - N_{it}) \tag{5}$$

3.2 Agents' program

3.2.1 Households

In each country, households consume a CES basket of the two goods varieties denoted C_{it}^c. As in Andolfatto [1996], we assume complete income insurance markets. Consequently, the optimal households' behavior is derived using a dynamic program where *ex-post* heterogeneity on the labor market does not matter: risk-averse households insure themselves fully against heterogeneous wealth positions.[7] We thus derive the optimal workers' decision rules by solving the program of a representative household.

The country i representative maximizes her expected intertemporal utility:

$$E_0 = \sum_{t=0}^{\infty} \beta^t \left[N_{it} U\left(C_{it}^n, \Gamma_{it}^n\right) + (1 - N_{it}) U(C_{it}^u, \Gamma_{it}^u) \right] \qquad i = 1, 2 \tag{6}$$

where $0 < \beta < 1$ is the discount factor. The time period is normalized to 1. C_{it}^n and C_{it}^u stand for the consumption of employed and unemployed agents, while Γ_{it}^n and Γ_{it}^u denote the utility of leisure for employed and unemployed workers respectively. N_{it} jobs are productive at the beginning of period t, which thus represents the probability of employment for each household's member.

As standard in Chéron and Langot [2004], we adopt additively separable preferences between consumption and leisure:

$$U\left(C_{it}^z, \Gamma_{it}^z\right) = \log\left(C_{it}^z\right) + \Gamma_{it}^z \qquad z = n, u \tag{7}$$

with $\Gamma_{it}^n = \kappa_i^n \frac{(1-h_{it})^{1-\xi}}{1-\xi}$ and $\Gamma_{it}^u = \kappa_i^u$. ξ is the inverse of the intertemporal elasticity of substitution of leisure. In what follows, we present the optimizing program in country 1. The (symmetric) program of the Foreign household is reported in Appendix B.

[6] Following Andolfatto [1996] and the subsequent related literature, the distinction between unemployed and not in the labor force is ignored in the model.

[7] This is equivalent to consider a "large" family whose members, employed and unemployed, pool their incomes to maximize the expected life-time utility of the representative household. For further details see Andolfatto [1996].

The intertemporal program The country 1 household maximizes the expected discounted sum of her utility flows (6), subject to a sequence of two constraints, the law of motion of employment (5) and her budget constraint (expressed in terms of numéraire):

$$\begin{aligned} P_{1t}^{c}(1+\tau_1^c)[N_{1t}C_{1t}^{n}+(1-N_{1t})C_{1t}^{u}] \quad + \quad & B_{1t+1}+P_{1t}^{c}CA_{1t} \leq N_{1t}w_{1t}h_{1t}(1-\tau_1^d) \\ & +(1-N_{1t})b_{1t}+B_{1t}(1+i_t)+T_{1t}+\Pi_{1t}^{F} \end{aligned} \tag{8}$$

As in CHRISTOFFEL and LINZERT [2005], we assume that, when employed, household members receive the wage payments $w_{1t}h_{1t}$, net of direct taxes (τ_1^d), while, when unemployed, they receive unemployment benefits which are evaluated in consumption units, b_{1t}.[8] Both the real wage and the unemployment benefit are paid in terms of the locally produced good. The household's resources are also made of international financial assets. We retain the assumption of incomplete financial markets, as a large strand of the related literature underlines the role of this assumption in the international transmission of shocks (GHIRONI [2006] or DUARTE and STOCKMAN [2001]). Each period, a no-risk interest rate bond is issued (in terms of numéraire); when subscribed in period t, it yields a no-risk nominal interest rate i_t in $t+1$. The household also receives transfers from the government T_{1t} and the end-of-period profits as the owner of the local firms (Π_{1t}^F).

The period's resources are used for consumption (given the consumption tax rate τ_1^c), demand for international assets B_{1t+1}, and adjustment costs on these assets ($P_{1t}^c CA_{1t}$), these costs being defined in terms of the Home composite good. As discussed by GHIRONI [2006], the introduction of incomplete asset markets alters the property of stationarity of the model, since temporary shocks have permanent effects on macroeconomic variables. Recent related literature proposes alternative ways of avoiding non-stationarity. We follow KOLLMANN [2004], by assuming that the household faces adjustment costs when increasing her stock of international assets. These costs are scaled by the parameter $\Phi_b > 0$, according to:[9]

$$CA_{1t} = \frac{\Phi_b}{2}\left[\frac{B_{1t+1}}{P_{1t}^c}\right]^2 \tag{9}$$

As detailed below, each period worked hours and wage (before tax) $\{h_{1t}, w_{1t}\}$ are the Nash-bargaining result of negotiations between firms and workers. When solving the intertemporal program, the household consequently takes them as given. The optimization program is written as a Bellman equation:

$$\mathcal{V}\left(\mathcal{S}_{1t}^H\right) = \max_{\{C_{1t}^n, C_{1t}^u, B_{1t+1}\}} \left\{N_{1t}U(C_{1t}^n, h_{1t}) + (1-N_{1t})U(C_{1t}^u) + \beta E_t V\left(\mathcal{S}_{1t+1}^H\right)\right\} \tag{10}$$

[8] One can also interpret b_{it} as home production of a non-tradable good. We favor the interpretation in terms of unemployment insurance that will be calibrated in the next section.

[9] SCHMITT-GROHE and URIBE [2003] investigate the quantitative differences implied by alternative approaches in the literature to induce stationarity. They find that all versions deliver virtually identical dynamics at business cycle frequencies.

under the constraints (5) and (8), with the household's state variables $\mathcal{S}_{1t}^{H} = \{N_{1t}, B_{1t}\}$. First-order conditions with respect to consumption, nominal bonds and money holdings are respectively:

$$\begin{aligned} \frac{1}{C_{1t}^{n}} &= \frac{1}{C_{1t}^{u}} = (1+\tau_1^c)\lambda_{1t} P_{1t}^{c} & (11) \\ \lambda_{1t}\left(1 + \Phi_b \frac{B_{1t+1}}{P_{1t}^{c}}\right) &= \beta E_t\left[\lambda_{1t+1}(1+i_{t+1})\right] & (12) \end{aligned}$$

with λ_{1t} the multiplier associated with the budget constraint (8).

As shown by Equation (11), the optimal household's decisions rules imply identical aggregate consumption levels across the household's members, whatever their employment status:

$$C_{1t}^{n} = C_{1t}^{u} = C_{1t}^{c} \tag{13}$$

The intratemporal program The household consumes a basket of Home and Foreign varieties, according to the following CES specification:

$$C_{1t}^{c} = \left[\kappa^{\frac{1}{\eta}} C_{1t}^{\frac{\eta-1}{\eta}} + (1-\kappa)^{\frac{1}{\eta}} C_{2t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{14}$$

with $0 < \kappa < 1$ and $\eta \geq 1$. C_{1t} denotes Home consumption of the local variety, C_{2t} Home consumption of the Foreign variety, with $(1-\kappa)$ the share of imported goods. η is the elasticity of substitution between Home and Foreign varieties.

Optimal allocation between national varieties by the Home household for consumption motives leads to the following demand functions:

$$\begin{aligned} C_{1t} &= \kappa \left[\frac{P_{1t}}{P_{1t}^{c}}\right]^{-\eta} C_{1t}^{c} & (15) \\ C_{2t} &= (1-\kappa)\left[\frac{P_{2t}}{P_{1t}^{c}}\right]^{-\eta} C_{1t}^{c} & (16) \end{aligned}$$

with the associated expression for the Home consumption price index P_{1t}^{c}:

$$P_{1t}^{c} = \left[\kappa P_{1t}^{1-\eta} + (1-\kappa) P_{2t}^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{17}$$

with P_{it} the price of good i. The Home good is chosen as numéraire, hence its price is normalized to 1. We denote by $P_t \equiv P_{2t}/P_{1t}$ the (relative) price of the Foreign good. P_t corresponds to the terms of trade for the Foreign country (*i.e.* the relative price of exported goods to imported goods). An increase in P_t corresponds to an appreciation of the terms of trade for the Foreign country.

3.2.2 Firms

In each country, firms perfectly compete with each other in the production of an homogenous good. At the world-wide level, the two goods are imperfect substitutes. Both goods are produced using capital and labor as production factors, using a constant return to scale technology:

$$Y_{it} = A_{it} K_{it}^{\alpha} (N_{it} h_{it})^{1-\alpha} \qquad \text{for} \quad i = 1, 2 \tag{18}$$

with $0 < \alpha < 1$. K_{it} is the capital stock, N_{it} labor force and h_{it} worked hours. A_{it} designs the technology level in country i. It is assumed to follow a joint first-order autoregressive stochastic process:

$$\log A_{1t+1} = \rho_a \log A_{1t} + \rho_{a12} \log A_{2t} + (1 - \rho_a - \rho_{a12}) \log \overline{A} + \varepsilon_{1,t+1}^a + \psi_a \varepsilon_{2t+1}^a \tag{19}$$

$$\log A_{2t+1} = \rho_a \log A_{2t} + \rho_{a12} \log A_{1t} + (1 - \rho_a - \rho_{a12}) \log \overline{A} + \varepsilon_{2,t+1}^a + \psi_a \varepsilon_{1t+1}^a \tag{20}$$

where $\log \overline{A}$ is the mean of the process and $\{\varepsilon_i^a\}_t$ is the vector of technological innovations serially independent in country i, with $E[\varepsilon_1^a] = E[\varepsilon_2^a] = 0$. We adopt a general specification by allowing some cross-country correlation in the technological processes through ρ_{a12}. Besides, technological innovations are correlated across countries through ψ_a.

Investment in each country is assumed to be a CES bundle of the Home and Foreign varieties, with the same structure as the consumption one. The law of motion of physical capital is given by:

$$K_{it+1} = (1 - \delta) K_{it} + I_{it}^c \tag{21}$$

with $0 < \delta < 1$ the capital depreciation rate. Besides, firms face quadratic costs on adjusting capital, paid in terms of the composite good. These costs are specified as in Ireland [2001]:

$$CI_{it} = \frac{\Phi_I}{2} \frac{\left[K_{it+1} - K_{it}\right]^2}{K_{it}} \tag{22}$$

with $\Phi_I > 0$. Finally, labor-market frictions require firms to post vacant jobs (V_{it}), at the cost ω_i per vacant job (in terms of the composite good as well).

We present here the program of Home firms (the program of Foreign firms is reported in Appendix B). The program of each firm in country 1 consists of maximizing the expected discounted sum of profit flows (expressed in terms of numéraire):

$$\mathcal{W}(K_{1t}, N_{1t}) = \max \left\{ \begin{array}{c} Y_{1t} - w_{1t} h_{1t} N_{1t} \left(1 + \tau_1^f\right) - P_{1t}^c I_{1t}^c - \omega_1 P_{1t}^c V_{1t} \\ -P_{1t}^c CI_{1t} + \beta E_t \left[\frac{\lambda_{1t+1}}{\lambda_{1t}} \mathcal{W}(K_{1t+1}, N_{1t+1})\right] \end{array} \right\} \tag{23}$$

subject to the technological constraint (18), the law of motion of capital (21) and that of the labor force given by:

$$N_{1t+1} = (1 - s_1) N_{1t} + q_{1t} V_{1t} \tag{24}$$

with $q_{1t} = H_{1t}/V_{1t}$ the probability that a vacant job is matched. $0 < \tau_1^f < 1$ is the employer's labor tax rate. As Home firms are hold by the representative household, the discounted rate is the ratio of the multipliers associated with the budget constraint, since that ratio reflects the consumer's variation in wealth. Let us also define z_{it} and Tobin's q_{it}^T for $i = 1, 2$ as:

$$
\begin{aligned}
z_{it} &= \frac{1}{P_{it}^c} \alpha \frac{Y_{it}}{K_{it}} && (25) \\
q_{it}^T &= 1 + \Phi_I \frac{I_{it}^c - \delta K_{it}}{K_{it}} && (26)
\end{aligned}
$$

The optimality conditions are:

$$
q_{1t}^T = \beta E_t \left[\frac{P_{1t+1}^c \lambda_{1t+1}}{P_{1t}^c \lambda_{1t}} \left\{ z_{1t+1} + q_{1t+1}^T - \delta + \frac{\Phi_I}{2} \left(\frac{I_{1t+1} - \delta K_{1t+1}}{K_{1t+1}} \right)^2 \right\} \right] \tag{27}
$$

$$
\frac{\omega_1}{q_{1t}} = \beta E_t \left[\frac{P_{1t+1}^c \lambda_{1t+1}}{P_{1t}^c \lambda_{1t}} \left\{ \frac{1}{P_{1t+1}^c} (1 - \alpha) \frac{Y_{1t+1}}{N_{1t+1}} - \frac{w_{1t+1} h_{1t+1}}{P_{1t+1}^c} \left(1 + \tau_1^f \right) + (1 - s_1) \frac{\omega_1}{q_{1t+1}} \right\} \right] \tag{28}
$$

Equation (27) represents the optimal choice of capital accumulation. Firms invest in physical capital until the cost of investment (q_{1t}^T) equals the expected return on investment. Equation (28) highlights the trade-off faced by firms regarding job posting. Firms are enticed to post vacant jobs such as the cost of posting ($\frac{\omega_1}{q_{1t}}$) is equal to the expected return of a match.

3.2.3 Negotiating the labor contract

Each period, the labor contract stipulating the real wage (w_{it}) and the number of worked hours (h_{it}) is bargained between firms and employed workers according to the Nash criterion. In doing so, we retain the efficient Nash-bargaining process framework, where both wage and worked hours are negotiated, rather than the "right-to-manage" setting. The right-to-manage setting (where only the real wage is negotiated and firms freely choose hours) is found to better reproduce persistence in wage and inflation dynamics by Christoffel and Linzert [2005] and Christoffel, Kuester and Linzert [2006]. Since these are not our primary focus, we rather adopt the efficient Nash-bargaining framework, following, in doing so, Hairault [2002], Chéron and Langot [2004], Trigari [2004] or Campolmi and Faia [2006] among others.

In each country $i = 1, 2$, the bargaining process is given by the solution to the Nash criterion:

$$
\max_{w_{it}, h_{it}} \left[\lambda_{it} J_{it}^F \right]^\epsilon \left[J_{it}^H \right]^{1-\epsilon} \tag{29}
$$

with $J^F = \partial \mathcal{W} / \partial N$ the marginal value of a match for a firm (in country i) and $J^H = \partial \mathcal{V} / \partial N$ the marginal value of a match for a worker. $0 < \epsilon < 1$ denotes the firm's share of a job's value. In country 1, the optimal contract with respect to hours and wage satisfies the following equations: (See Appendix B for further details).

$$\frac{\kappa_1^n}{\lambda_{1t}}(1-h_{1t})^{-\xi} = \frac{1-\tau_1^d}{1+\tau_1^f}(1-\alpha)\frac{Y_{1t}}{N_{1t}h_{1t}} \tag{30}$$

$$w_{1t}h_{1t} = \frac{1-\epsilon}{1+\tau_1^f}\left[\omega_1 P_{1t}^c\theta_{1t} + (1-\alpha)\frac{Y_{1t}}{N_{1t}}\right] + \frac{\epsilon}{1-\tau_1^d}\left[b_{1t} + \frac{1}{\lambda_{1t}}\left(\kappa_1^u - \kappa_1^n\frac{(1-h_{1t})^{1-\xi}}{1-\xi}\right)\right] \tag{31}$$

with $\theta_{1t} \equiv \frac{V_{1t}}{U_{1t}}$ the labor market tightness in country 1. In Equation (30), hours are bargained so that marginal return of worked hours (right-hand side) equates the worker's marginal disutility of labor expressed in terms of real wealth (left-hand side).

In Equation (31), the representative worker's wage bill is a weighted average of *i)* the worker's contribution to output, plus hiring costs per unemployed workers (first term on the right-hand side of (31)), and *ii)* the worker's outside options, that are related to the gap between unemployed and employed workers expressed in terms of real wealth (second term on the right-hand side of (31)). As underlined by Christoffel and Linzert [2005], under efficient Nash-bargaining, any change in wage is accompanied by a change in hours, so that the "true" measure of firms' marginal labor cost is not the real wage, but the household's marginal rate of substitution of consumption and leisure (Equation (30)).

3.2.4 The government

Each period, the government has a balanced budget. Resources provided by taxes are transferred to the local household, as exogenous transfers and unemployment benefits. We assume that the unemployment benefit is constant ($b_{it} = b_i$) so that transfers T_{it} endogenously adjust to balance the government's budget constraint.

$$\tau_1^c P_{1t}^c C_{1t}^c + \left(\tau_1^d + \tau_1^f\right) N_{1t}w_{1t}h_{1t} = T_{1t} + (1-N_{1t})b_{1t} \tag{32}$$

$$\tau_2^c P_{2t}^c C_{2t}^c + \left(\tau_2^d + \tau_2^f\right) P_t N_{2t}w_{2t}h_{2t} = T_{2t} + (1-N_{2t})b_{2t} \tag{33}$$

3.2.5 Equilibrium

The model is closed by taking into account the equilibrium conditions on the following markets:

- Financial markets:

$$B_{1t+1} + B_{2t+1} = 0 \tag{34}$$

- Home good market:

$$Y_{1t} = \kappa\left(\frac{1}{P_{1t}^c}\right)^{-\eta} D_{1t}^c + (1-\kappa)\left(\frac{1}{P_{2t}^c}\right)^{-\eta} D_{2t}^c \tag{35}$$

- Foreign good market:

$$Y_{2t} = \kappa \left(\frac{P_t}{P^c_{2t}}\right)^{-\eta} D^c_{2t} + (1-\kappa)\left(\frac{P_t}{P^c_{1t}}\right)^{-\eta} D^c_{1t} \tag{36}$$

- The composite good market

$$P^c_{1t} D^c_{1t} + P^c_{1t} D^c_{2t} = Y_{1t} + P_t Y_{2t} \tag{37}$$

with D^c_{it} the aggregate demand in country $i = 1, 2$:

$$D^c_{it} = C^c_{it} + I^c_{it} + \omega_i V_{it} + CI_{it} + CA_{it} \tag{38}$$

Taking into account the different market equilibrium conditions in the household's budget constraint, we obtain the law of of motion of financial assets in the Home country, that is the evolution of its balance of payments:

$$B_{1t+1} - (1+i_t)B_{1t} = Y_{1t} - P^c_{1t} D^c_{1t} \tag{39}$$

After having determined the long-run equilibrium, equations are log-linearized around the steady state. The model is solved using Farmer's [1993] methodology.

4 Capturing divergence in labor market institutions

Calibration of structural parameters is made on a quarterly basis. Since the paper focuses on the role of cross-country divergence in the labor market functioning, we introduce an asymmetric the calibration of the related structural parameters. Our calibration strategy relies on the following arbitrage. As underlined by the empirical labor market literature (Blanchard and Wolfers [2000], Belot and Van Ours [2004] among others), there is a large amount of cross-country heterogeneity in the various dimensions of labor market regulations of OECD countries. This calls for an asymmetric calibration of all related parameters. However, given our aim at confronting the model's quantitative predictions to the data, calibration requires to be based on empirically plausible values. If we can find data to calibrate some LMIs parameters (such as tax rates) asymmetrically across countries, this is not the case for some others (such as the matching technology parameters). In that case, we set the same calibration for both countries, based on values usually retained in the literature.

As far as empirical estimates are available in the literature, values for country 1 are thus set so as to mimic the United States, *i.e.* the "flexible economy", while values for country 2 attempt to mimic the French economy, qualified as the "rigid" one. Our choice of calibrating on France and the United-States is consistent with information provided by the LMI dataset for the sample of 15 OECD countries used in Section 2. We indeed check that LMI values for France are higher than the median value of the country sample (*i.e.* that France features relatively more rigid LMIs), while those for the United-States are lower.

[Insert Table 3 here]

Labor market heterogeneity is introduced though the following dimensions (top panel of Table 3).

- Cross-country heterogeneity in the labor market functioning is first captured by the steady-state value of unemployment. The higher unemployment rate since the 1970s is indeed a key distinctive feature of the continental European labor markets as compared to Anglo-Saxon countries. Accordingly, the steady-state values of N are set to 0.93 and 0.91, so as to reproduce the standardized unemployment rates observed in the US and in France, based on data provided by the OECD over the 1982-1998 period.

- We capture the cross-country divergence in tax wedge through the calibration of tax rates. $(\tau_i^f, \tau_i^d, \tau_i^c)$ are set to the corresponding average tax rates in France and the United States over 1982-1998, based on data provided by NICKELL [2006].[10] For τ_i^c, we use the "indirect tax rate", for τ_i^d the "direct tax rate" and for τ_i^f the "Employment tax rate" (as denoted by NICKELL [2006]). This allows to model cross-country difference in tax wedges.

- We capture differences in the generosity of the unemployment insurance system between the USA and France through the calibration of b_i. We calibrate the steady-state ratio $\frac{b}{wh}$ on the empirical ratio (provided by NICKELL's [2006] database) defined as the average ratio across the first five years of unemployment for three family situations and two earning levels, in France and in the United-States.[11]

- One major difference between the US and the French labor markets lies in the mean duration of unemployment. We model this heterogeneity through the calibration of the probability of finding a job (ϕ in the model), as it is inversely related to the average duration of unemployment. The quarterly value of ϕ for the flexible country is based on HALL's [2005] estimates of a mean unemployment duration of three months and a half in the US. For the rigid country, we use data on the duration of unemployment (in months) for France provided by the OECD.[12]

[10] Calibration related to LMI parameters is based on data averaged over 1982-1998. The sample starts in 1982 because of data availability constraints, namely regarding the mean duration of unemployment used to get ϕ.

[11] Nickell's database provides other benefit replacement ratios, such as "brr_1" that refers to the first year of unemployment benefits, averaged over three family situations and two earning levels. Calibrating on this ratio would imply higher values than those considered here. However, results would not be substantially modified since the cross-country difference remains of the same magnitude.

[12] We use data provided by the OECD. Data is available over the period 1982-1998.

Data indicates an average duration of unemployment of around one year. This implies a quarterly value of the probability of finding a job equal to 0.187 in France versus 0.6345 in the US.

- Given the calibration for N and using the steady-sate relation derived from Equation (5) $sN = \phi(1-N)$, this leads to a value for the job destruction rate equal to $s_1 = 0.0478$ and $s_2 = 0.0185$. We interpret the lower job destruction rate (hence, the lower magnitude of job flows) in country 2, as resulting from more stringent EPLs. This view is consistent with empirical papers (surveyed in Cahuc and Zylberberg [2004]) showing that stringent EPLs reduce job destruction (as well as job creation). A similar interpretation of s is made in Christoffel and Linzert [2005].

The other LMI parameters are set identical across countries, and equal to values commonly used in the labor market RBC literature (bottom panel of Table 3). As in Campolmi and Faia [2006] or Chéron and Langot [2004], we set the weight of vacant jobs V in the matching function to $\psi = 0.6$. We preserve the Hosios condition by setting the bargaining power of firms in the Nash-bargaining $\epsilon = 0.6$ as well. As a result, wage and hours bargaining is such that trade externalities on the labor market do not distort equilibrium. The probability q that a vacant job is matched is set to 0.88, based on the estimates of ϕ and labor market tightness in US data ($\theta = 0.72$, Hall [2005]) and given the steady-state relationship $q = \theta/\phi$. This calibration of q lies within the range of values commonly found in the literature ($q = 0.7$ in Den Haan, Ramey and Watson [2000] or Krause and Lubik [2007], $q = 0.9$ in Andolfatto [1996] or Hairault [2002]).[13] We calibrate the cost of job posting by setting $\bar{\omega}V/Y = 0.015$. This calibration lies within the range of values used in the literature (0.005 in Chéron and Langot [2004], 0.01 in Hairault [2002], or 0.05 in Krause and Lubik [2007]).

Calibration of technological and preference parameters are reported in Tables 4 and 5. α captures to the elasticity of output with respect to capital, estimated to 0.36 by Kydland and Prescott [1982] on US data. The discount factor β is set to 0.99, which corresponds to a real annual interest rate equal to 4%, as in Campolmi and Faia [2006]. The depreciation rate of capital is about 10% a year, implying $\delta = 0.025$ on a quarterly basis. Calibration of ξ is based on estimated of the labor-supply elasticity ϵ_h, given the steady-state relation $\xi = \frac{1-h}{h}\epsilon_h$. The literature does not reach some clear-cut consensus regarding the value of ϵ_h. As in Chéron and Langot [2004] and Hairault [2002], we choose $\xi = 4$, so that the average individual labor supply elasticity is equal to 0.5, consistently with micro-estimates (MaCurdy [1981]). The steady-sate value for worked hours is set to $h = 1/3$ (Chéron and Langot [2004]). $(1-\kappa)$ represents the steady-state value of

[13] We check that our main results on GDP comovement are left unaffected by the calibrated value of q. Results are not reported here for sake of space saving but they are available upon request.

imports to GDP. Kollmann [2001] suggests a value of $(1-\kappa)$ of 0.1 in the United States, while Campolmi and Faia [2006] set $(1-\kappa)$ equal to 0.4 for European countries. We set $(1-\kappa)$ to an intermediate value of 0.15 in both countries, as in Hairault [2002]. For G7 countries, empirical papers estimate that the elasticity between Home and Foreign varieties η lies between 0 and 1.5 (Hooper and Marquez [1995]). We follow the literature (Corsetti and Pesenti [2001] among others) by setting $\eta = 1$. Based on the empirical results of Lane and Milesi-Ferretti [2001] on major developed countries and as in Kollmann [2004], Φ_b is calibrated so that $\Phi_b/NX = 0.0038$, with NX the steady-state value of exports. The capital adjustment costs parameter Φ_I is taken from Patureau [2007] and close to Kollmann [2001]. Table 4 summarizes the previous calibrated values.

[Insert Table 4 here]

Table 5 reports the calibration of technological stochastic process in the model. It is taken from Backus, Kehoe and Kydland [1995]. Using this calibration allows to compare our results with related studies (Hairault [2002], Campolmi and Faia [2006]), by using the same variability and persistence in aggregate shocks.

[Insert Table 5 here]

The empirical results reported in Section 2 suggest that labor market heterogeneity reduces the extent of business cycle synchronization, as compared to the case when both countries are similar and featured with flexible labor market regulations. Besides, the design of LMIs *per se* also matters, as countries with similar stringent employment protection laws have less correlated business cycles. Next sections investigate the relevance of the model to account for these stylized facts.

5 Labor market institutions and macroeconomic dynamics

This section studies the role of labor market heterogeneity on the dynamic behavior of macroeconomic variables in response to exogenous technological shocks, relying on IRF analysis. On that side, one may study IRFs to symmetric shocks (*i.e.* common to both countries) or to asymmetric shocks. In the advent of common shocks, countries with similar LMIs will respond identically to the common supply shock, whatever the design of labor market regulations (rigid or flexible). It is thus trivial that cross-country divergence in LMIs will cause asymmetric responses between the two countries' macroeconomic aggregates following a common shock. The model therefore predicts that asymmetric LMIs reduce GDP comovement in the advent of common shocks.

The more interesting case deals with the way labor market heterogeneity alters the international propagation mechanism of country-specific shocks. We study here the case of a positive technological shock in the Home country (country 1). When countries are symmetric, the IRFs are then quite close to Hairault's [2002] results. We consequently go short on commenting the propagation mechanisms underlying these IRFs, to focus on the role of the design in LMIs in the international propagation of Home supply shocks. Following a 1% increase in A_1, IRFs are thus reported in three cases (Figures 1-3): when countries are characterized by symmetric and flexible LMIs ("Flex-Flex" case), when they feature symmetric and rigid LMIs ("Rig-Rig" case) and when they have asymmetric LMIs, country 1 featuring more flexible labor market regulations than country 2 ("Flex-Rig" case).

[Insert Figure 1 here]

[Insert Figure 2 here]

[Insert Figure 3 here]

The rationale underlying these IRFs can conveniently be organized in three points. First, we focus on the symmetric flexible case. Secondly, starting from this "benchmark" case, we evaluate how it is affected by the design of LMIs. Thirdly, we assess the role of labor market heterogeneity in GDP comovement.

The symmetric flexible case We focus here on IRF analysis when countries are symmetric in any respect, featuring flexible labor market regulations (Country 1's calibration in Table 3). IRFs to a Home positive supply shock are then quite close to Hairault's [2002] results, so that we only summarize here the main mechanisms at work.

- Consider first the effects of the shock on impact (period 1). Increase in Home production (Figure 1) comes from two sources, the direct effect of the total factor productivity shock and the increase in individual worked hours, given the predetermined levels of employment and capital stocks (Figure 2). With the international spillover of the supply shock, similar (even though weaker) effects occur in the Foreign country. In both economies, despite the positive wealth effect of the supply shock, households agree to bargain over a larger amount of worked hours as long as it is associated with an increase in the real wage (Figure 3). Due to search frictions, Home firms start posting vacancies as soon as the shock occurs, so as to be able to produce more the second period by an adjustment through the extensive margin (the number of jobs) rather than the intensive margin (hours). Given the international transmission of the supply shock, Foreign firms react similarly. As a result, vacancies increase in both countries (Figure 3). However, responses of vacant jobs and production are substantially larger in the Home economy directly hit by the increase in total factor productivity.

- From the second period onwards, firms in both countries can adjust through the extensive rather than the intensive margin. The negotiated amount of individual worked hours falls because of the positive wealth effect induced by the supply shock. This comes along with a reduction in the negotiated wage (Figure 3). Given the dynamics of the employment level and individual hours, total employment gradually increases in both countries (before coming back to its steady-state level). This internal propagation mechanism induces a positive comovement in employment across countries.

  The particular dynamics of employment induced by search-labor market frictions interact with that of capital investment. As reported in Figure 2, domestic investment rises on impact, given the increase in capital productivity induced by the Home supply shock. After the second period, the instantaneous effect of the Home supply shock is filled in by the gradual increase in total employment, which drives Home capital productivity upwards. This explains the gradual increase in Home investment in response to the Home supply shock. Interaction between capital and employment dynamics also play a key role in explaining the IRFs of Foreign investment. Higher employment in country 2 partially offsets the capital outflow by increasing the marginal productivity of capital, leading to a positive comovement in investment, similarly to HAIRAULT's [2002] results.

Outputs in both countries inherit the gradual adjustments in capital and employment stocks. As shown in Figure 1, this results in a gradual increase in Home and Foreign productions, leading to a positive international comovement in GDP following the Home supply shock.

Aggregate dynamics and the design of labor market institutions : flexible versus rigid LMIs The extent of international comovement is affected by the design of LMIs. When countries have stringent labor market regulations, firms are less enticed to post vacant jobs in response to the Home supply shock (Figure 3). Gradual increase in the employment level is accordingly much more limited, which contributes to explain the lower increase in total hours in the rigid LMI case (Figure 1).

Rigid LMIs induce more sluggishness in the responses of vacancies and the employment level. As a result, adjustment occurs relatively more through the intensive margin (worked hours), as may be inferred from Figure 2. During the transition dynamics, reduction in worked hours is all the more limited as countries have rigid LMIs. In that case indeed, firms are willing to compensate for the weak increase in the employment level by bargaining over an increase in worked hours. This mechanism is also reflected in the responses of real wages (Figure 3). When stringent labor market regulations limit the adjustment through the employment stock, worked hours decrease less, which the households agree on a higher wage. As a result, with flexible LMIs, total hours (Nh) display a hump-shape behavior while the hump-shape disappears in the case of rigid LMIs.

As reported in Figure 2, Home investment dynamics is substantially affected by the design of LMIs. These differences in investment dynamics are related to the dynamics of total hours (Nh) as they affect the marginal productivity of capital. As a result, we observe in the Home country a delayed investment boom in case of flexible LMIs versus a smooth dynamics in the case of rigid LMIs.

The output dynamics inherits those of the employment and capital stocks. Output response differ across LMIs because total hours *and* capital responses are sensitive to the LMI regime. In the case of stringent LMIs, the monotonic adjustment in investment dynamics and the much smoother and weaker increase in total hours imply that Home output immediately rises with the Home technological shock, to monotonically come back to its steady-state level. In the Foreign country, the rise in output is progressive in any case, but the magnitude of expansion is much weaker when the country features rigid LMIs. Stringent LMIs thus induce divergent GDP responses to the country-specific shock, thereby lowering international GDP comovement.

Labor market heterogeneity and GDP comovement Figures 1, 2 and 3 make clear that heterogeneity in LMIs matters in the international propagation of the supply shock. With flexible LMIs in the Home country, rises in Home employment, investment or output are more limited when the Foreign country exhibits stringent labor market regulations, relative to the symmetric flexible case.

Since rigid LMIs limit the magnitude of the increase in Foreign output and more generally in Foreign macroeconomic aggregates, expansion is weaker at the world-wide level in the asymmetric case. As compared to the symmetric flexible case, Home output does not need to increase as much. Heterogeneity in LMIs thus affects the international propagation of the Home technological shock according to a general equilibrium effect.

The IRF analysis to the Home supply shock leads the following comments. First, it shows that labor market heterogeneity affects the international propagation of supply shocks, whether the shocks are common or country-specific. Secondly, the level of LMIs matters as well. The overall rigidity of labor markets limits the responses of macroeconomic aggregates (investment, employment and output) to exogenous shocks. These results are consistent with the stylized facts obtained in Section 2. Next section evaluates the model's quantitative implications.

6 Labor market institutions and business cycle comovement

In this section, we assess the model's quantitative results with regard to international comovement, when the model is hit by technological innovations. As with the IRF analysis, common shocks as well as country-specific shocks may be contemplated. In the advent of common shocks (*i.e.* with ψ_a set to 1 in Table 5), the model predicts an unitary cross-country GDP correlation as long as countries have identical LMIs, and whatever their design (flexible or rigid). Conversely, it is trivial that introducing cross-country divergence in LMIs will lower cross-country GDP correlation below 1. The model thus predicts that labor market heterogeneity reduces the extent of business cycle comovement in the advent of common shocks.

We then assess the model's predictions in the advent of country-specific (even though cross-country correlated) technological innovations. This case is more empirically relevant, since estimates of technological processes typically get a less-than-perfect transmission degree of country-specific innovations (as illustrated by Backus, Kehoe and Kydland's [1995] estimates in Table 5). Table 6 thus displays the cross-country correlation of output, total worked hours and investment simulated by the model, based on the calibration of technological shocks reported in Table 5. As in Section 5, we compare the model's predictions in the three "LMI regimes": *i)* when LMIs in both countries are flexible (column (B), "*Flex-Flex*" case), *ii)* when LMIs differ across countries, Country 1 featuring flexible LMIs and Country 2 rigid ones (column (C), "*Asym.*" case), and *iii)* when LMIs in both countries are rigid (column (D), "*Rig-Rig*" case). Column (A) of Table 6 reports the same statistics observed in the data, taken from Backus, Kehoe and Kydland [1995]. These data correspond to the median value of the correlations observed with the same US variable of a sample of 10 OECD countries over the period 1970-mid 1990s.[14] Table 6, column (E) reports the results of tests of equality of means between the cross-country correlation of the symmetric flexible case and that of the asymmetric case. The null assumption H_0 is that both correlations are statistically equal (the alternative being that they differ). Similarly, column (F) reports results when testing equality of means between the symmetric rigid case and the asymmetric case.

[Insert Table 6 here]

Results that emerge from Table 6 may be summarized in three points.

First, the model is able to rationalize the stylized fact that the cross-country design of LMIs induces significant differences in international GDP comovement. Empirical results in Section 2 suggest that the cross-country GDP correlation of a country pair significantly differs, depending on whether the two countries have similar LMIs or not, and on whether their labor market may be qualified as rigid or flexible. The model is consistent with this empirical result. As shown in Table 6, the cross-country GDP correlation differs depending on the LMI regime (comparing columns (B), (C) and (D)). This is also the case with respect to the cross-country correlations of employment and

[14] Note that Backus, Kehoe and Kydland [1995] report the cross-country correlation of employment rather than that of total worked hours. Empirical evidence reported by Ambler, Cardia and Zimmermann [2004] suggest that both are very close.

investment. Notice that the differences across regimes are statistically significant, as shown by the results of the tests of equality of means reported in columns (E) and (F). For all macroeconomic aggregates, the mean cross-country correlations in the asymmetric case statistically differ from those obtained in the symmetric flexible case, and from those obtained in the symmetric rigid case.

Secondly, the model predicts a significantly lower cross-country GDP correlation when countries feature divergent LMIs, as compared to the flexible symmetric case. This is consistent with the stylized facts in Section 2, and in line with the IRF analysis in Section 5. This conveys the message that we have to take into account labor market heterogeneity if we are willing to explain the cross-country GDP correlation among OECD countries. The predicted cross-country correlations of macroeconomic aggregates are too high as compared to the data. This suggests that another source of shocks than technological ones is needed to help disentangle movements in macroeconomic variables across countries.

Thirdly, the model accounts for the stylized fact that the overall level of labor market rigidity of a country pair reduces their business cycle synchronization. As shown in Table 6, the lower GDP correlation is obtained when both countries feature rigid LMIs (column (D)), consistently with the data. This can be rationalized recalling the IRF analysis in Section 5. This section indeed makes clear that labor market rigidity substantially dampens the magnitude of the responses of investment, output and employment to asymmetric shocks. It is henceforth not surprising that, when two countries featured with rigid LMIs are subject to country-specific innovations, macroeconomic aggregates in each country weakly respond, thereby leading to a lower cross-country correlation.

Results reported in Table 6 suggest that taking into account the design of LMIs improves our understanding of international comovement among OECD countries. We complete the quantitative evaluation of the model by deriving its predictions regarding within-country business cycle properties. First, this allows to check that simulated moments (whatever the design of LMIs) are not at odds with the data. Secondly, this enables us to evaluate the role of the LMI design (flexible or rigid) on within-country business cycle properties. Results are displayed in Table 7.

Table 7, columns (A) to (D) reports within-country moments simulated by the model in the three LMI regimes. Columns (E) and (F) reports the same statistics observed in the USA and France respectively, as they can be considered as representative of countries with flexible and rigid LMIs respectively.[15]

[Insert Table 7 here]

[15] Empirical moments are based on own calculations, based on quarterly series for France and the USA over the period 1973-1998, except for the correlation between unemployment and vacancies (Corr(U, V)). This statistics is taken from Krause and Lubik [2007] for the United-States, and from Fève and Langot [1996] for France. Further details are provided in Appendix A.

The model matches the order of volatility, as investment (consumption) is more (less) volatile than output. Regarding correlations with output, the model's predictions are in line with the data, even though correlations are slightly too large. The model predicts a negative correlation between unemployment and vacant jobs. After a positive technological shock, unemployment falls, while firms post more vacant jobs. The model is thus able to replicate the so-called Beveridge curve.

Table 7 allows to evaluate the role of labor market rigidity on within-country business cycle properties. The main result is that labor market rigidity reduces the volatility of the main macroeconomic aggregates (output, total employment or investment). This is in line with the IRF analysis (Section 5), that shows that labor market rigidity exerts a dampening effect on the responses of these variables to supply shocks. Notice that this result is consistent with stylized facts observed in France and the United-States (columns (E) an (F)). As shown by the IRF analysis, adjustment to supply shock occurs more through intensive margin (worked hours) than extensive margin (employment) when countries feature stringent LMIs. As a result in that case, the model predicts a volatility of total employment lower than that of labor productivity, which is not in line with French data. However, and due to the same mechanism, comparing France with the US data, the model correctly accounts for the larger volatility in labor productivity and its larger correlation with GDP in the rigid LMI country. In addition, as in the data, the correlation between unemployment and vacancies is more negative with flexible LMIs: Vacancies are filled more rapidly, which results in a lower unemployment rate.

Whatever the labor market design, flexible or rigid, the model overestimates the volatility of the real wage and its correlation with GDP. This counterfactual result is not surprising though, given the standard search and matching model adopted here. As noted by Krause and Lubik [2007], in this setting workers and firms share the surplus obtained from their match. The negotiated wage thus monotonically depends of the labor market tightness θ, *i.e.* the ratio between vacancies and unemployment. Since labor market tightness is highly volatile in the model in the occurrence of technological shocks, the real wage is strongly volatile too, which is counterfactual. Shimer [2005] and Hall [2005] then argue that introducing a real wage rigidity improves the performances of the model of that side. This is done in Section 6.2. The model also fails to replicate the large volatility of terms of trade found in the data. This is a well-known limit of real business cycle models, that only rely on technological shocks (Backus, Kehoe and Kydland [1995], Hairault [2002]). As shown by the literature, improvements on that side may come from the introduction of monetary shocks in a framework with monopolistic competition and nominal price rigidities (Kollmann [2001]).

6.1 Sensitivity analysis

Previous results have been obtained considering three sources of cross-country labor market heterogeneity between continental European labor markets (France) and Anglo-Saxon countries (the

US): heterogeneity in tax wedges (*i.e.* in τ^c, τ^f and τ^d), unemployment benefit ratio (*i.e.* b/wh) and probability of finding a job (ϕ), that we interpret more broadly as heterogeneity in the degree of employment protection.

Yet, one may wonder whether all dimensions of labor market heterogeneity substantially matter in international comovement, and whether all complement each other in reducing GDP comovement. To investigate this point further, we derive the model's predictions with respect to GDP comovement when countries differ regarding one single LMI dimension at a time. Table 8 reports the results. In columns (C), (D) and (E), countries respectively differ in the employment protection degree (EPL), in benefit ratio brr and in tax wedge tw. In each case, the other LMI parameters have been set to the flexible LMI case (country 1 in Table 3). For sake of comparison, Table 8 also reports the results when both countries have flexible labor markets (column (A)) and when all three LMI dimensions differ (column (B)). In each case, we check whether the mean cross-country GDP correlation significantly differs from the symmetric flexible case, by running a test of equality of means (reported on the last two lines of Table 8).

[Insert Table 8 here]

First, each dimension of labor market heterogeneity (EPL, unemployment benefits and tax wedge) significantly affects the extent of GDP comovement. In each case, we reject the null assumption that the cross-country GDP correlation is statistically equal in the symmetric and asymmetric LMI regime.

Secondly, Table 8 shows that heterogeneity in employment protection is the dimension that matters most in reducing GDP comovement (column (C)). Divergence in EPL implies a significantly lower cross-country GDP correlation as compared to the flexible symmetric case. This result is consistent with the stylized facts in Section 2. Empirical analysis indeed shows that difference in employment protection is the most robust channel through which labor market heterogeneity affects GDP comovement.

Thirdly, Table 8 reports that divergence in the generosity of the unemployment insurance system reduces business cycle synchronization (column (D)). In that case, the cross-country GDP correlation is significantly lower than in the symmetric flexible case. This last result contradicts the empirical facts of Section 2, where differences in unemployment benefit ratios were estimated to have no significant role in GDP comovement of OECD countries. This counterfactual result may be related to the leading role of the wage bargaining process on labor market adjustments in the model. Since unemployment benefits intervene in workers' outside option in the Nash bargaining, they have a strong role in affecting the negotiated values of the real wage and hours, hence in the implied dynamics of vacant jobs, employment level and output. Table 8 suggests that the model gives too much role to unemployment benefits through the Nash bargaining process as far as GDP comovement is concerned. Improvement may be achieved on that point by introducing a real wage rigidity in the model, since it disentangles the effective real wage in the economy from the negotiated value resulting from the Nash-bargaining. We explore the relevance of this intuition in the next section.

6.2 Adding real wage rigidity

There is a vivid debate in the labor market literature regarding the role of real wage stickiness, initiated by HALL's [2003] and SHIMER's [2005] papers. They argue that this mechanism substantially improves the ability of DSGE models to account for the correlation between unemployment and vacancies. CHRISTOFFEL and LINZERT [2005] show that it helps reproduce wage and inflation dynamics. More closely related to our paper, CAMPOLMI and FAIA [2006] obtain that, with real wage rigidity, asymmetric LMIs contribute to explain persistent inflation differentials across European countries. These results lead us to modify the model to introduce a real wage rigidity. In line with our previous sensitivity analysis, we particularly focus on the way real wage rigidity affects the impact of labor market heterogeneity on GDP comovement.

We thus develop a variant of the model featured by a real wage stickiness *à la* HALL [2003]. As in CHRISTOFFEL and LINZERT [2005], the effective real wage is a weighted average of the wage resulting from the Nash-bargaining process (given by Equation (31) and denoted w_{it}^{NB}), and a social norm $\widetilde{w}_{it}$. Following HALL [2005], we adopt the adaptive wage specification, such as $\widetilde{w}_{it} = w_{it-1}$. In country i and period t, the effective real wage is then written as:

$$w_{it} = (1-\mu)w_{it}^{NB} + \mu w_{it-1} \tag{40}$$

with $0 < \mu < 1$ the weight attributed to the social norm in the effective wage. One standard way to capture the degree of real wage rigidity in the related literature is to pick up the value of μ so as to match the average frequency of wage renegotiations. We set $\mu = 0.889$ following GERTLER and TRIGARI [2009], implying that wage contracts are renegotiated on average every three quarters in accordance with US data. This calibration lies within the range of values frequently met in the related literature (CHRISTOFFEL and LINZERT [2005], CHRISTOFFEL and KUESTER [2008], among others). Quantitative results are reported in Tables 9, 10 and 11.

[Insert Table 9 here]

First, the effects of labor market heterogeneity on business cycle synchronization remain robust to the introduction of real wage rigidity. The model still predicts that asymmetric LMIs significantly reduce the cross-country correlation of outputs, investments and labor inputs as compared to the case when both countries have flexible LMIs. Correlations are even lower in the symmetric rigid

LMI case, in line with the data. Secondly, as compared to Table 6, cross-country correlations of macroeconomic aggregates are slightly larger in presence of real wage rigidity. Given wage stickiness, adjustments to exogenous shocks are achieved by more adjustments in quantities. For a similar reason, volatility in GDP increases in presence of real wage stickiness, as shown by the comparison of Tables 7 and 10. Besides, and as expected, the volatility of the real wage is substantially reduced when allowing for real wage rigidity, in line with the literature's findings (Table 10).

[Insert Table 10 here]

In Table 11, we evaluate the effects of each dimension of labor market heterogeneity on GDP comovement in presence of a real wage rigidity. This yields interesting results. With real wage rigidity, asymmetric unemployment benefits or taxes no longer play a significant role in GDP comovement (Columns (D) and (E)). In contrast, the dampening impact of heterogeneity in the degree of employment protection on GDP comovement remains robust to the introduction of real wage stickiness. These results have a straightforward explanation. With sluggish wages indeed, labor market institutions that primarily affect the Nash-bargaining process (*i.e.*, unemployment benefits and tax wedges) have a reduced impact on labor market adjustments, thereby on GDP synchronization.

[Insert Table 11 here]

These results confirm our previous findings that employment protection is the main channel through which labor market heterogeneity affects GDP comovement (Table 8). In presence of real wage stickiness, divergence in EPL remains the LMI dimension with a significant dampening effect on business cycle synchronization.

7 Conclusion

The paper investigates the role of cross-country divergence in LMIs on international comovement. We first document stylized facts on the link between labor market heterogeneity and GDP comovement among OECD countries. We find that cross-country divergence in employment protection significantly reduces international GDP comovement. The design of labor market regulations also matters, as the overall degree of labor market rigidity in a country pair is found to reduce further the cross-country GDP correlation.

We then investigate this stylized fact within the international RBC model with labor-market frictions, that we amend to take into account asymmetric LMIs. As in Hairault [2002], labor market frictions are modelled through a matching function *à la* Pissarides [1990]. Labor market heterogeneity is introduced through cross-country differences in tax wedge, unemployment benefit ratio and the probability of finding a job for a worker, that we view more broadly as capturing differences in employment protection. Calibration on the related LMI parameters is based on the United-States (the "flexible" country) and France (the "rigid" one).

We find that the model rationalizes the stylized fact that labor market heterogeneity substantially affects GDP comovement. In quantitative terms, the model predicts that asymmetric LMIs significantly reduce cross-country GDP correlation, as compared to the case when both countries have flexible LMIs. GDP correlation is even lower when both countries feature stringent labor market regulations, consistently with the data. These results are robust to the introduction of real wage rigidity.

The paper thus suggests that taking into account the design of LMIs among OECD countries is important if we are willing to account for their business cycle synchronization. The finding that labor market heterogeneity matters in international GDP comovement may be of particular interest for policy makers, notably from the Euro zone's perspective. It thus supports the view, that harmonization of European labor markets can ease the conduct of the European Central Bank's monetary policy. This suggests to further investigate the appropriate design of monetary policy in the context of asymmetric labor markets.

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A Data description and sources

We use data coming from the BSDB OECD database to calculate the cross-country GDP correlation. We consider quarterly series of GDP (at factor cost), in volume at constant prices, over the period 1973:2-1998:4. Data inspection for German macroeconomic series suggests a structural break on German data due to the German reunification, that the model cannot account for. Based on the methodology proposed by Milliard, Scott and Sensier [1997], we detect outliers on the series converted into growth rates. This leads to identify one outlier (1990:1). The corresponding point in the series taken in growth rate is therefore replaced by averaging the closest growth rates. The GDP series is then converted back into level.[16]

In Section 6, we report within-country moments for France and the United-States. They have been calculated using quarterly series for both countries over the period 1973:2-1998:4. Series for investment and consumption are raw data from the BSDB OECD database. Using this database, we obtain real wage series deflating the nominal wage (compensation per employee, private sector, current prices) by the deflator of private consumption. We build the series for total worked hours (Nh) by combining the total employment series in the business sector (N) with series for worked hours per employee (h), obtained from OECD.stat. German series have been corrected for German reunification. The business cycle components of all series are then captured using the Hodrick and Prescott [1997] filter.

LMI variables are coming from the database provided by Nickell [2006], based on OECD data. We retain the following variables:

- *Employment protection laws (all workers).* It is an index that ranges in 1-2, increasing with strictness of employment protection. It consists of the laws, regulations and administrative decisions that constraint the contractual conditions under which a worker can be dismissed; the laws and regulations relating to the compensation an employer is obliged to pay when regulations determining remedies for wrongful or unfair dismissal.

- *Union coverage.* Union coverage refers to the number of workers covered by collective agreements normalized on employment. In the labor market literature (see Belot and Van Ours [2004], among others), this variable is intended to capture the unions' bargaining power.

- *Tax wedge.* It constitutes the wedge between the real product wage (labor costs per employee normalized on the output price) and the real consumption wage (after tax pay normalized on the consumer price index). This variable (in percent) is equal to the sum of the employer's tax rate (employer's social security contributions as % of wages and salaries), the direct tax

[16]However, we check that the stylized facts reported in Section 2 are robust to the absence of treatment of German data.

rate (amount of direct taxes as % of households' current receipts) and the indirect tax rate (total indirect tax as % private final expenditures).

- *Benefit replacement ratio.* It is the gross benefit replacement rate. The benefits are a percentage of average earnings before tax. We consider the original benefit replacement rates data published by the OECD. It is defined as the average across the first five years of unemployment for three family situations and two money levels.

Nickell's (2006) database delivers information regarding 20 OECD countries. For each country and LMI variable, we take the mean value over the period. For each LMI dimension and for each country pair, we calculate the absolute value of the cross-country difference in the LMI values, as a measure of labor market heterogeneity.

The country list initially includes 20 OECD countries. We remove Ireland, Norway and Switzerland because of the large number of missing values in LMI variables. We also remove Australia and New Zealand, since they clearly appear as outliers when inspecting the correlation between cross-country GDP correlation and divergence in LMIs. This yields a set of 15 OECD countries: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Portugal, Spain, Sweden, the United-Kingdom and the United-States (105 country-pairs).

The volume of bilateral trade ("Bilat. trade") is taken from Andrew Rose's webpage[17]. The variable is defined as the sum of the bilateral import and export trade flows between the two countries of the pair (i, j), divided by the sum of countries i and j import and export flows to/from all countries. We take the average value over the last three decades (*i.e.* over 1974-2004).

B Complements to the model

B.1 The Foreign household's program

The intertemporal program Similarly as in country 1, the real wage and the unemployment benefit in country 2 are expressed in terms of Foreign good. The Foreign household's optimization program is written as a Bellman equation:

$$\mathcal{V}(B_{2t}, N_{2t}) = \max_{\{C^n_{2t}, C^u_{2t}, B_{2t+1}\}} \{N_{2t}U(C^n_{2t}, h_{2t}) + (1 - N_{2t})U(C^u_{2t}) + \beta E_t V(B_{2t+1}, N_{2t+1})\} \tag{B.1}$$

subject to the employment law of motion (Equation (5)) and the Foreign household's budget constraint, expressed in terms of numéraire:

$$P^c_{2t}(1 + \tau^c_2)[N_{2t}C^n_{2t} + (1 - N_{2t})C^u_{2t}] + B_{2t+1} + P^c_{2t}CA_{2t} \leq P_t N_{2t} w_{2t} h_{2t}(1 - \tau^d_2) \tag{B.2}$$

$$+(1 - N_{2t})P_t b_{2t} + B_{2t}(1 + i_t) + T_{2t} + P_t \Pi^F_{2t} \tag{B.3}$$

[17] http://faculty.haas.berkeley.edu/arose

The first-order conditions are similar to those in the Home country:

$$\frac{1}{C_{2t}^n} = \frac{1}{C_{2t}^u} = (1+\tau_2^c) P_{2t}^c \lambda_{2t} \tag{B.4}$$

$$\lambda_{2t}\left(1 + \Phi_b \frac{B_{2t+1}}{P_{2t}^c}\right) = \beta E_t\left[\lambda_{2t+1}(1+i_{t+1})\right] \tag{B.5}$$

with λ_{2t} the multiplier associated with the Foreign household's budget constraint.

The intratemporal program The Foreign household consumes a basket of Home and Foreign varieties, according to the following CES specification:

$$C_{2t}^c = \left[\kappa^{\frac{1}{\eta}} \left[C_{2t}^*\right]^{\frac{\eta-1}{\eta}} + (1-\kappa)^{\frac{1}{\eta}} \left[C_{1t}^*\right]^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{B.6}$$

with $0 < \kappa < 1$ and $\eta \geq 1$. C_{2t}^* denotes Foreign consumption of the Foreign variety, C_{1t}^* Foreign consumption of the Home (imported) variety.

Given the choice of the Home good as the numéraire good, the Foreign household's optimal allocation between the two goods leads to the following demand functions, for the Home and Foreign varieties respectively:

$$C_{2t}^* = \kappa \left(\frac{P_t}{P_{2t}^c}\right)^{-\eta} C_{2t}^c \tag{B.7}$$

$$C_{1t}^* = (1-\kappa) \left(\frac{1}{P_{2t}^c}\right)^{-\eta} C_{2t}^c \tag{B.8}$$

The associated consumption price index in country 2 is:

$$P_{2t}^c = \left[\kappa P_t^{1-\eta} + (1-\kappa)\right]^{\frac{1}{1-\eta}} \tag{B.9}$$

B.2 The program of the Foreign firms

The program of the Foreign firms is to maximize the expected discounted sum of profit flows (expressed in terms of numéraire):

$$\mathcal{W}(K_{2t}, N_{2t}) = \max \left\{ \begin{array}{c} P_t Y_{2t} - P_t w_{2t} h_{2t} N_{2t}\left(1+\tau_2^f\right) - P_{2t}^c I_{2t}^c - \omega_2 P_{2t}^c V_{2t} \\ -P_{2t}^c CI_{2t} + \beta E_t\left[\frac{\lambda_{2t+1}}{\lambda_{2t}} \mathcal{W}(K_{2t+1}, N_{2t+1})\right] \end{array} \right\} \tag{B.10}$$

subject to the technological constraint (18), the law of motion of capital (21) and that of the labor force:

$$N_{2t+1} = (1-s_2) N_{2t} + q_{2t} V_{2t} \tag{B.11}$$

The first-order conditions are given by:

$$q_{2t}^T = \beta E_t \left[\frac{P_{2t+1}^c \lambda_{2t+1}}{P_{2t}^c \lambda_{2t}} \left\{P_{t+1} z_{2t+1} + q_{2t+1}^T - \delta + \frac{\Phi_I}{2}\left(\frac{I_{2t+1} - \delta K_{2t+1}}{K_{2t+1}}\right)^2\right\}\right] \tag{B.12}$$

$$\frac{\omega_2}{q_{2t}} = \beta E_t \left[\frac{P^c_{2t+1}\lambda_{2t+1}}{P^c_{2t}\lambda_{2t}} \left\{ \frac{P_{t+1}}{P^c_{2t+1}} (1-\alpha) \frac{Y_{2t+1}}{N_{2t+1}} - w_{2t+1} h_{2t+1} \frac{P_{t+1}}{P^c_{2t+1}} \left(1+\tau_2^f\right) + (1-s_2) \frac{\omega_2}{q_{2t+1}} \right\} \right] \tag{B.13}$$

B.3 Solving the labor contract

This section details the solving of the Nash-bargaining process, that leads to Equations (30) and (31) in country 1. The marginal discounted value of a match for a firm in country 1 is defined by:

$$J^F_{1t} = \frac{\partial \mathcal{W}_{1t}}{\partial N_{1t}} \tag{B.14}$$

that becomes, given the firm's optimizing problem presented in Section 3.2.2:

$$J^F_{1t} = (1-\alpha)\frac{Y_{1t}}{N_{1t}} - w_{1t}h_{1t}(1+\tau_1^f) + (1-s_1)\beta E_t \left[\frac{\lambda_{1t+1}}{\lambda_{1t}} J^F_{1t+1} \right] \tag{B.15}$$

As well, let J^H_{1t} define the marginal discounted value of a match for the worker as:

$$J^H_{1t} = \frac{\partial \mathcal{V}_{1t}}{\partial N_{1t}} \tag{B.16}$$

Given the household's optimizing problem detailed in Section 3.2.1 and the employment law of motion (5), it becomes:

$$J^H_{1t} = \kappa_1^n \frac{(1-h_{1t})^{1-\xi}}{1-\xi} - \kappa_1^u + \lambda_{1t}\left[w_{1t}h_{1t}(1-\tau_1^d) - b_{1t} \right] + (1-s_1-\phi_{1t})\,\beta E_t J^H_{1t+1} \tag{B.17}$$

The Nash-bargaining criterion that firms and household attempt to solve is given by:

$$\max_{w_{1t},h_{1t}} \left(\lambda_{1t}J^F_{1t}\right)^{\epsilon} \left(J^H_{1t}\right)^{1-\epsilon} \tag{B.18}$$

with $\lambda_{1t}J^F_{1t}$ the marginal value of the match for the firm, expressed in terms of the household's marginal utility of wealth. The first-order condition associated with w_{1t} leads to the following surplus sharing-role:

$$J^H_{1t} = \frac{1-\epsilon_1}{\epsilon_1} \frac{1-\tau_1^d}{1+\tau_1^f} \lambda_{1t} J^F_{1t} \tag{B.19}$$

As shown by Equation (B.19), labor taxes, whether they are paid by the employer or by the employee, reduce the surplus that is shared through the Nash-negotiation.

In country 2, firms and workers bargain over the real wage and the amount of worked hours, so as to maximize the surplus of a match. The optimal contract with respect to hours and wage satisfies the following equations:

$$\frac{\kappa_2^n}{\lambda_{2t}}(1-h_{2t})^{-\xi} = \frac{1-\tau_2^d}{1+\tau_2^f} P_t (1-\alpha) \frac{Y_{2t}}{N_{2t}h_{2t}} \tag{B.20}$$

$$w_{2t}h_{2t} = \frac{1-\epsilon}{1+\tau_2^f}\left[\omega_2 \frac{P_{2t}^c}{P_t}\theta_{2t} + (1-\alpha)\frac{Y_{2t}}{N_{2t}}\right] + \frac{\epsilon}{1-\tau_2^d}\left[b_{2t} + \frac{1}{P_t\lambda_{2t}}\left(\kappa_2^u - \kappa_2^n \frac{(1-h_{2t})^{1-\xi}}{1-\xi}\right)\right] \quad \text{(B.21)}$$

with $\theta_{2t} \equiv \frac{V_{2t}}{U_{2t}}$ the labor market tightness in country 2. As in country 1, the optimal household's decisions rules imply identical aggregate consumption levels across the foreign household's members, whatever their employment status:

$$C_{2t}^n = C_{2t}^u = C_{2t}^c \quad \text{(B.22)}$$

Table 1: Regression results (1)

	Dep. Variable: cross-country GDP correlation								
Model :	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
Diff. in *uc*	-0.002^a				-0.002				
	(0.001)				(0.002)				
Diff. in *brr*		0.001				-0.000			
		(0.002)				(0.002)			
Diff. in *tw*			-0.006^a				-0.000		
			(0.002)				(0.003)		
Diff. in EPL				-0.149^a				-0.237^a	-0.147^c
				(0.055)				(0.076)	(0.088)
Bilat. trade									0.014^b
									(0.006)
Obs	105	105	105	105	105	105	105	105	105
R^2	0.08	0.00	0.06	0.06	0.46	0.44	0.44	0.50	0.53
Country FE	No	No	No	No	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors into parenthesis, with ^{a}, ^{b} and ^{c} denoting significance at the 1%, 5% and 10% levels respectively. A constant term is included in the regressions.

Table 2: Regression results (2)

Model :	Dep. Var. ρ^y (A)	(B)	(C)
Diff. in EPL	-0.147c		
	(0.088)		
Both Rigid in EPL		-0.146^c	-0.248^c
		(0.080)	(0.140)
Both Flexible in EPL		0.209^a	0.211^b
		(0.078)	(0.081)
Bilateral trade	0.014b	0.017^a	0.015^a
	(0.006)	(0.006)	(0.006)
Both EMS			0.133
			(0.128)
Obs.	105	105	105
R^2	0.53	0.51	0.52

Notes: Robust standard errors into parenthesis, with ^{a}, ^{b} and ^{c} denoting significance at the 1%, 5% and 10% levels respectively. Country-fixed effects and a constant term are included in the regressions.

Table 3: Capturing labor market heterogeneity

		Country 1 *Flexible*	Country 2 *Rigid*
Unemployment rate	$1-N$	0.07	0.09
Probability of finding a job	ϕ	0.6345	0.187
Unemployment benefit ratio	b/wh	0.13	0.342
Employer's labor tax (in %)	τ^f	6.5	28.6
Employee's labor tax (in %)	τ^d	15.5	12.3
Indirect tax rate (in %)	τ^c	11.1	22.5
Weight of V in the matching function	ψ	0.6	
Weight of the firm in the match	ϵ	0.6	
Probability of matching a vacant job	q	0.88	
Cost of job vacancy posting	$\bar{\omega}V/Y$	0.015	

Table 4: Calibration of technological and preference parameters

α	β	δ	ξ	h	κ	η	Φ_I	$\frac{\Phi_b}{NX}$
0.36	0.99	0.025	4	0.33	0.85	1	7	0.0038

Table 5: Calibration of technological shocks

$\overline{A}$	ρ_a	ρ_{a12}	$\sigma_{\varepsilon a}$	ψ_{a12}
1	0.906	0.088	0.00852	0.13

Table 6: International comovement

	(A)	(B)	(C)	(D)	(E)	(F)
	Data	Model			Test of equality of means	
		Flex-Flex	*Asym.*	*Rig-Rig*	*Asym.* vs *Flex-Flex*	*Asym.* vs *Rig-Rig*
$\rho(Y_1, Y_2)$	0.51	0.620	0.564	0.541		
		(0.12)	(0.12)	(0.12)		
t-stat					10.45^a	4.08^a
Reject H_0					Yes	Yes
$\rho(Nh_1, Nh_2)$	0.36	0.862	0.811	0.846		
		(0.07)	(0.08)	(0.07)		
t-stat					15.20^a	10.38^a
Reject H_0					Yes	Yes
$\rho(I_1^c, I_2^c)$	0.38	0.480	0.376	0.319		
		(0.16)	(0.16)	(0.15)		
$t-$stat					15.80^a	8.13^a
Reject H_0					Yes	Yes

Notes: Simulated moments obtained with $n = 1000$ simulations. Standard deviations displayed into parenthesis. ^{a} associated with the $t-$statistics of equality of means means that the null assumption of equality of means is rejected at the 1% significance level.

Table 7: Within-country business cycles properties

	Flex-Flex	Rig-Rig	Asymmetric		Data	
			Flexible country	Rigid country	USA Flex	France Rig
	(A)	(B)	(C)	(D)	(E)	(F)
Standard deviation						
Y (in %)	1.478	1.23	1.464	1.235	1.67	0.95
C	0.539	0.603	0.524	0.625	0.81	0.99
I	1.720	1.738	1.682	1.781	2.79	3.70
Nh	0.590	0.235	0.570	0.243	1.04	0.91
Labor Productivity	0.646	0.852	0.651	0.851	0.51	0.70
w	1.630	1.225	1.604	1.238	0.53	0.67
Terms of trade	0.585	0.661	0.601		1.92	3.30
Correlation with Y						
C	0.993	0.990	0.993	0.989	0.868	0.682
I	0.991	0.990	0.990	0.992	0.812	0.822
Nh	0.780	0.701	0.782	0.688	0.878	0.736
w	0.605	0.937	0.622	0.932	0.403	0.09
Labor productivity	0.829	0.980	0.845	0.978	0.163	0.473
$\rho(U, V)$	-0.808	-0.455	-0.807	-0.453	-0.95	-0.6

Notes: Moments obtained with $n = 1000$ simulations. Standard deviations are relative to Y.

Table 8: Labor market heterogeneity: what dimension matters?

	Symmetric	Asymmetric LMIs			
	Flex-Flex	All LMIs differ	Differ in EPL	Differ in *brr*	Differ in *tw*
	(A)	(B)	(C)	(D)	(E)
$\rho(Y_1, Y_2)$	0.620	0.564	0.549	0.606	0.584
	(0.12)	(0.12)	(0.12)	(0.13)	(0.13)
t-stat		10.45^a	13.12^a	2.597^a	6.60^a
Reject H_0		Yes	Yes	Yes	Yes

Notes: Moments obtained with $n = 1000$ simulations. Standard deviations displayed into parenthesis. The $t-$ stat tests the equality of means between the symmetric flexible case (column (A)) and each asymmetric case (columns (B),(C), (D) and (E) respectively). ^{a} means that the null assumption H_0 of equality of means is rejected at the 1% significance level.

Table 9: International comovement, model with real wage rigidity

	(A)	(B)	(C)	(D)	(E)	(F)
	Data	Model			Test of eq. of means	
		Flex-Flex	*Asym.*	*Rig-Rig*	*Asym.* vs *Flex-Flex*	*Asym.* vs *Rig-rig*
$\rho(Y_1, Y_2)$	0.51	0.635	0.595	0.564		
		(0.11)	(0.12)	(0.12)		
t-stat					7.86^a	5.98^a
Reject H_0					Yes	Yes
$\rho(Nh_1, Nh_2)$	0.36	0.894	0.839	0.883		
		(0.04)	(0.06)	(0.06)		
t-stat					24.59^a	17.52^a
Reject H_0					Yes	Yes
$\rho(I_1^c, I_2^c)$	0.38	0.503	0.395	0.308		
		(0.14)	(0.16)	(0.17)		
t-stat					15.93^a	11.92^a
Reject H_0					Yes	Yes

Notes: Simulated moments obtained with $n = 1000$ simulations. Standard deviations displayed into parenthesis. ^{a} means that the null assumption of equality of means is rejected at the 1% significance level.

Table 10: Within-country moments, model with real wage rigidity

	Flex-Flex	Rig-Rig	Asymmetric		Data	
			Flexible country	Rigid country	USA Flex	France Rig
	(A)	(B)	(C)	(D)	(E)	(F)
Standard deviation						
Y (in %)	1.515	1.287	1.517	1.29	1.67	0.95
C	0.551	0.582	0.533	0.605	0.81	0.99
I	1.791	1.68	1.744	1.728	2.79	3.70
Nh	0.529	0.294	0.523	0.301	1.04	0.91
Labor Productivity	0.599	0.788	0.6	0.786	0.51	0.70
w	0.37	0.433	0.367	0.435	0.53	0.67
Terms of trade	0.57	0.636	0.584		1.92	3.30
Correlation with Y						
C	0.991	0.99	0.991	0.99	0.868	0.682
I	0.974	0.982	0.974	0.983	0.812	0.822
Nh	0.866	0.786	0.869	0.783	0.878	0.736
w	0.960	0.834	0.962	0.838	0.403	0.09
Labor Productivity	0.901	0.974	0.9055	0.9716	0.163	0.473
$\rho(U,V)$	-0.736	-0.431	-0.735	-0.432	-0.95	-0.6

Notes: Moments obtained with $n = 1000$ simulations. Standard deviations are relative to Y.

Table 11: Sensitivity analysis, model with real wage rigidity

	Symmetric	Asymmetric LMIs			
	Flex-Flex	All LMIs differ	Differ in EPL	Differ in brr	Differ in tw
	(A)	(B)	(C)	(D)	(E)
$\rho(Y_1, Y_2)$	0.635	0.595	0.592	0.636	0.635
	(0.11)	(0.12)	(0.12)	(0.11)	(0.11)
t-stat		7.86^a	8.56^a	0.25	0.124
Reject H_0		Yes	Yes	No	No

Notes: Moments obtained with $n = 1000$ simulations. Standard deviation displayed into parenthesis. The t-stat tests the equality of means between the symmetric flexible case (column (A)) and each asymmetric case (columns (B),(C), (D) and (E) respectively). ^{a} means that the null assumption H_0 of equality of means is rejected at the 1% significance level.

Figure 1: Dynamics following a home supply shock (1)

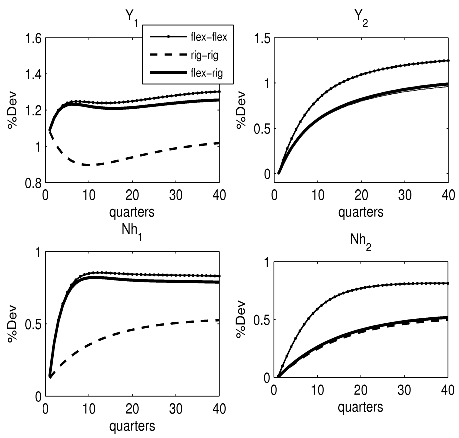

Figure 2: Dynamics following a home supply shock (2)

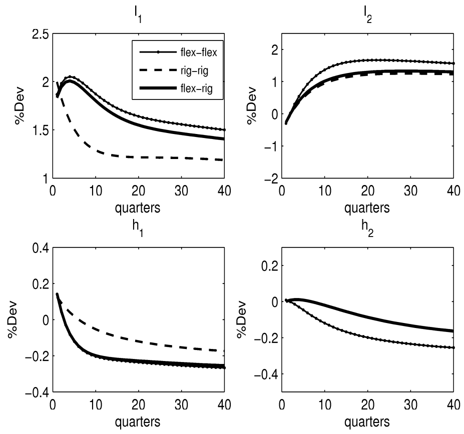

Figure 3: Dynamics following a home supply shock (3)