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The Shimer-Puzzle of International Trade: A Quantitative Analysis

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Abstract

Recent theoretical literature studies how labor market reforms in one country can affect labor market outcomes in other countries, thereby rationalizing widely-held policy beliefs and empirical evidence. But what is the quantitative relevance of such spillover effects? This paper combines two recent workhorse models: the canonical search-and-matching framework and the heterogeneous firms international trade model. Qualitatively, the framework confirms that labor market reforms in one country benefit its trading partners, replicating the stylized facts. However, when wages are bargained flexibly, the model quantitatively underestimates the correlation of structural unemployment rates across countries. This mirrors the well-known finding by Shimer (2005) by which the standard search-and-matching model predicts too small fluctuations of unemployment rates over time. Introducing real wage rigidity remedies this problem.

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1 Introduction

Inspired by a recent political debate, mostly in Europe, about the cross-country effects of labor market policies, a number of theoretical contributions have highlighted the interconnectedness of labor markets through international trade. However, in order to derive analytical results these models concentrate on specific channels and are too stylized to provide quantitative assessments. We close this gap by introducing search-and-matching unemployment into a multi-country trade model with heterogeneous firms. Comparing the quantitative predictions of the model with the empirical evidence, we find that the standard model with flexibly bargained wages underestimates the large spillovers found in the data. Allowing for real wage rigidity enables the model to replicate the size of empirically observed spillovers.

Based on a model incorporating search-and-matching frictions in a two-sector Melitz (2003) model, Helpman and Itskhoki (2010) find that a labor market reform in one country harms its trading partner. That correlation reverses without the presence of a linear, frictionless outside sector. This has been shown by Egger, Egger, and Markusen (2012) who use a framework with minimum wages and heterogeneous firms where spillovers work through *selection effects* in the distribution of firms within the sector. Felbermayr, Larch, and Lechthaler (2009, 2012) find a similar result based on an Armingtonian trade model with search-and-matching unemployment where spillovers operate through changes in the *relative price* of the output produced by a worker and the cost of hiring a worker (i.e., the cost of posting a vacancy). Both papers concentrate on a specific channel in order to derive analytical results. Due to their stylized nature, they cannot be sensibly used to make quantitative assessments.

Empirical evidence points towards a positive correlation of unemployment rates across countries and between foreign labor market distortions and domestic unemployment rates. Felbermayr, Larch, and Lechthaler (2012) show in a panel of 20 rich OECD countries controlling for business cycle comovements and an array of exogenous shocks and time dummies, that the effect of foreign institutions on domestic unemployment is about 10% of the effect of domestic institutions. Are the above proposed channels able to explain this magnitude of the spillovers observed in the data?

It is the aim of this paper to quantify the spillovers in a framework that simultaneously allows

for the selection effect and the relative-price effect. To do so, we develop a multi-country, asymmetric general equilibrium framework which combines two recent workhorse models, namely the monopolistic competition, heterogeneous firms trade model of Melitz (2003) and the search-and-matching approach of Mortensen and Pissarides (1994). To quantitatively assess institutional spillovers, we calibrate our model and simulate it. In line with previous findings, we find a positive correlation of changes in the home and foreign unemployment rates in response to changes in the labor market institutions of one country. However, our quantification shows that, in the basic setting with flexible wages, the spillover effects of foreign institutions on domestic unemployment are only about 1% of the effect of domestic institutions. Hence, the spillover is only a tenth of the empirically observed one. We also show that the strength of the correlation depends on the size and centrality of countries. However, neither of them is able to contribute substantially enough to bring the theoretically predicted size of the spillover closer to the empirically observed ones. We call this finding the *Shimer-puzzle of international trade*, in analogy to the findings of Shimer (2005), that the standard search-and-matching model can only explain about 10% of the business-cycle fluctuations of unemployment.

Shimer (2005) has sparked a hot debate in the macro-labor literature and initiated a new literature trying to solve the Shimer-puzzle. While up to date the issue is not yet solved, probably the most prominent solution is to assume some sort of wage rigidity (see, e.g., Hall (2005a)). We therefore contrast the analysis where wages are perfectly flexible, with the opposite extreme assumption of perfect real wage rigidity. The lack of adjustment in prices naturally increases the scope of adjustment in quantities. Hence, real wage rigidity should increase spillovers in terms of unemployment rates. Our simulation shows that with perfect real wage rigidity, spillovers to the foreign country can amount to up to 45% of the effect in the originating country. Hence, the *Shimer-puzzle of international trade* can be solved by combining search-and-matching unemployment with some real wage rigidity.

Concerning the different channels, our model is sufficiently general to capture both the relative-price effect of Felbermayr, Larch, and Lechthaler (2012) and the selection effect of Egger, Egger, and Markusen (2012). The relative-price effect appears because labor market reforms that reduce the labor market frictions at home lower the domestic wage and thereby the domestic price. This lowers the aggregate price index in Foreign, because its imports become

cheaper. Thus, the price of foreign goods goes up relative to the foreign price index and thereby the marginal revenue product of labor goes up relative to the cost of vacancy posting (which is denominated in the price index). This incentivizes firms to post more vacancies and leads to a *positive correlation* of unemployment rates. The relative-price effect is important in order to generate a positive correlation between unemployment rates, but not sufficient to match empirically observed magnitudes.

In our setup, heterogeneity at the firm-level is not crucial for the sign of the spillovers.[1] However, firm heterogeneity matters for the quantitative implications of labor market reforms, which is the focus of the present paper. Selection of firms compounds the effects discussed above. When Home reduces its unemployment rate, income and demand for products goes up. On the one hand, this induces foreign market entry so that the relative weight of the most productive firms in Foreign – the exporters – goes up, improving aggregate productivity there. On the other hand, foreign entry increases cost-competitiveness of Home exporters which makes it harder for inefficient firms in Foreign to survive, again pushing up aggregate productivity. Firm selection therefore strengthens the *positive correlation* between countries' unemployment rates. Our quantitative analysis shows that firm heterogeneity is not elemental to match the sign of empirically observed labor market spillovers, but helps to match the size.

By adopting a single-sector structure, our setup is geared towards trade in differentiated goods which makes up the lion's share of total trade amongst OECD countries for which the existing evidence applies. This choice mutes the *comparative advantage* channel present in Davis (1998) or Helpman and Itskhoki (2010). While the former model stresses cross-country heterogeneity in relative capital-labor endowments, the latter features sector-level differences with regard to the importance of search frictions. In Davis (1998), an increase in unemployment benefits at home leads to higher unemployment at home, inducing an increase in the relative capital-labor abundance. A relatively capital-rich home economy specializes more strongly on capital-intensive goods while the foreign country produces more of the labor-intensive goods.

[1] In contrast, in Egger, Egger, and Markusen (2012) heterogeneity is crucial for the sign of the spillovers and is needed in order to have binding minimum wages (and thus unemployment) in several countries. Noteworthy, the assumptions of heterogeneous firms and binding minimum wages are two main ingredients helping to align theoretical predictions and empirical findings.

Labor demand in the foreign country goes up and the marginal value product of labor increases. Firms create more vacancies, which leads to a fall in unemployment. The opposite logic applies if the home country is labor-rich. Hence, the sign of the correlation of unemployment rates between countries depends crucially on the comparison of capital-labor ratios across countries. Besides the ambiguous predictions concerning the correlation of unemployment rates, empirical studies focusing on the determinants of trade flows find hardly any evidence for the comparative advantage channel. Hence, we will focus on the empirically relevant channel for developed countries, based on differentiated goods and economies of scale.

The remainder of the paper is structured as follows. Section 2 presents simple stylized facts about the cross-country correlations of unemployment rates. Section 3 outlines the theoretical model. Section 4 describes the calibration. Section 5 discusses four main results of the model. Section 6 presents some robustness checks. Section 7 concludes.

2 Stylized Facts

We briefly show two stylized facts: (i) Domestic and foreign unemployment rates are positively correlated across countries; (ii) Domestic unemployment rates and foreign labor market distortions are positively correlated across countries.

Figure 1 illustrates stylized fact (i). It shows the share of positive, negative, and statistically insignificant bilateral correlations between unemployment rates of 20 OECD countries in the period 1963-2008, where short-run business cycles are purged by taking 5-year averages. Unemployment rates are usually positively correlated over time within country pairs. Negative correlations are very rare.[2]

To illustrate fact (ii), it is convenient to summarize foreign variables as trade weighted averages. That is, foreign variables are weighted by a proxy for bilateral trade volumes. The left panel of Figure 2 below shows natural logs of yearly domestic unemployment rates for 20 OECD countries (including France, Germany, Japan, UK, USA) and the period (1990-2003) on

[2]Egger, Egger, and Markusen (2012) look at the comovement of the aggregate EU rate of unemployment and the US one, and find that they are strongly positively correlated over time. They interpret this finding as evidence for fact number (i).

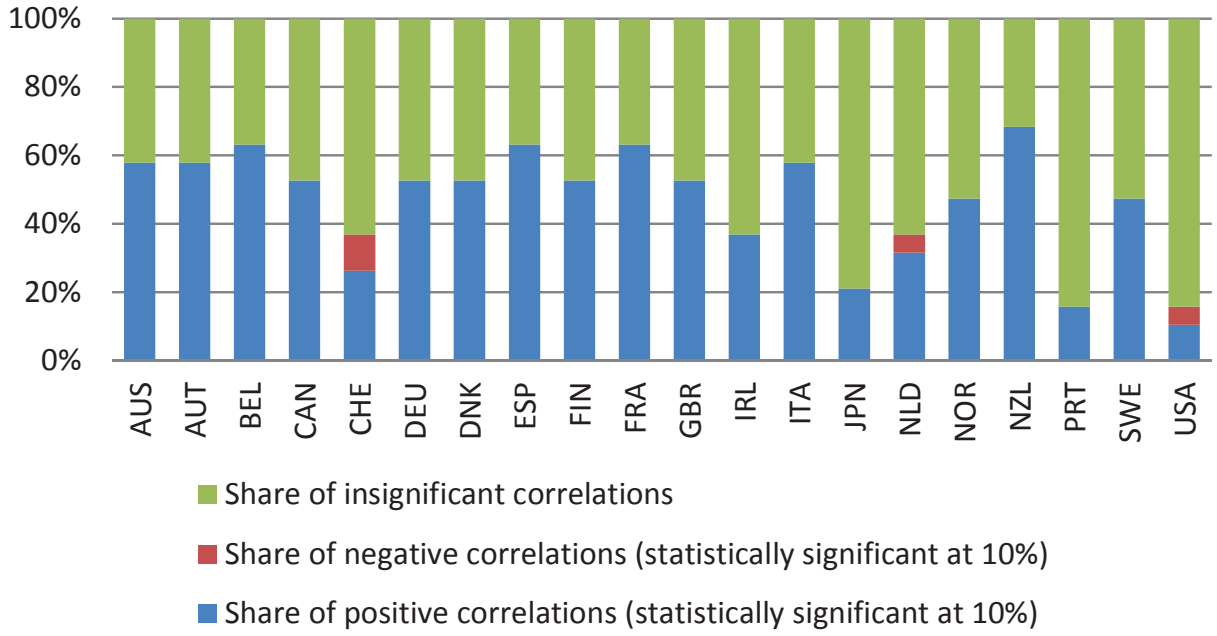

Figure 1: Bilateral correlations of unemployment rates, 5-year windows.

the y-axis. On the x-axis, it plots corresponding foreign rates. A naive linear robust bivariate regression (taking account of outliers) yields a slope coefficient of 0.094 with an associated t-value of 3.77, which provides stylized evidence for fact (i). The right panel repeats this exercise, but plots the foreign tax wedge (the sum of unemployment benefit replacement rates and labor taxes, a commonly used measure of total labor market distortions) on the x-axis. There is again a strong positive relation, with a slope estimate of 0.075 and a t-value of 3.08, providing evidence for fact (ii).

While those data are suggestive, Felbermayr, Larch, and Lechthaler (2012) go beyond a descriptive analysis. The positive correlation of unemployment rates across space may be driven by common business cycles, by changes in labor and product market regulations and by other sources of country-specific heterogeneity. To account for these issues, they include measures of the domestic and the foreign output gaps as well as a host of orthogonal macro shocks and year dummies to deal with business cycle effects. Additionally, they control for domestic and foreign product market regulation (including trade openness) and purge unobserved country-specific heterogeneity by adding fixed effects. Their results can be summarized as follows: (i) Foreign labor market distortions increase the domestic unemployment rate. On average, domestic distortions are about 10 times more important than foreign ones. (ii) More central

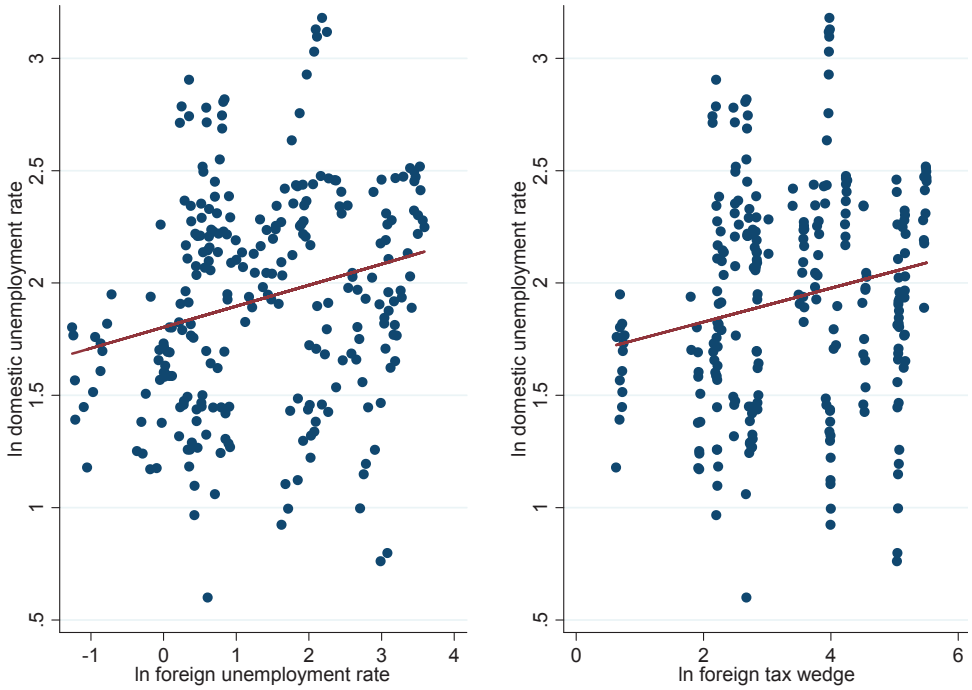

Figure 2: Foreign unemployment rates and labor market distortions are positively correlated to domestic unemployment.

(and, hence, more open) countries are more strongly subject to foreign institutional changes. If trade openness converges to zero, spillovers vanish. (iii) Smaller economies are more strongly affected. E.g., an increase in the foreign unemployment rate by one percentage point increases the German unemployment rate by about 0.04 points while the Austrian rate would go up by twice as much. The model we are now presenting can replicate all qualitative effects, but has a hard time matching the quantitative aspects, in analogy to the Shimer(2005)-puzzle of the macro-labor literature. We will show that real wage rigidity can solve this problem.

3 Model Setup

Our modeling strategy consists in combining two absolutely standard models from the literature, which are frequently and successfully used in quantitative exercises: the Melitz (2003) trade model with Pareto-distributed productivities, and the Mortensen-Pissarides (1994) search-and-matching labor market approach. In that setup, unemployment is a function of observable determinants, such as unemployment benefits, so that calibration of the model is straight-forward. We use the the Melitz model, because it generalizes the Krugman (1980) model, which supplies

additional moments to be matched to the data. It also provides an additional channel through which labor market institutions in one country affect outcomes in its trading partners, influencing the quantification at the heart of our analysis. Clearly, for our argument, we need a model with asymmetric countries to study the effects of institutional differences. Moreover, in order to capture trade diversion effects and investigate the role of geography for institutional transmission, we require at least three countries.[3] Since we want to quantify the labor market spillover effects amongst the OECD countries and our argument only rests on the existence of a relative-price effect and a selection effect and not on comparative advantages, a single-sector perspective is enough.

3.1 Demand for intermediate inputs

Our world consists of N potentially asymmetric countries, indexed by subscript i, with $i = 1, ..., N$. Countries have work forces denoted by L_i and labor is the only factor of production. In each country, firms produce a final output good Q under perfect competition. That good is assembled from a continuum of intermediate inputs, indexed by ω, and supplied by domestic and foreign firms who operate under conditions of monopolistic competition. The final output good can be consumed or used by input producers. The aggregate production function in country i is

$$Q_i = \left\{ (\bar{M}_i)^{\frac{\nu-1}{\sigma}} \int_{\omega \in \Omega_i} q[\omega]^{\frac{\sigma-1}{\sigma}} d\omega \right\}^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $q[\omega]$ denotes the quantity of intermediate input ω, and $\sigma > 1$ is the elasticity of substitution between any two varieties. The set of available intermediate inputs in country i, Ω_i, has measure $\bar{M}_i$. The parameter $\nu \in (0, 1)$ governs the extent of *external economies of scale*: If $\nu = 0$ the number of available varieties is irrelevant for total output, as in Blanchard and Giavazzi (2003). If $\nu = 1$ we obtain the case discussed by Krugman (1980) or Melitz (2003).

Similar to Melitz (2003), intermediate input firms are uniquely described by different productivity levels φ and place of origin, so that we can substitute the firm index ω with φ and index prices and quantities with country subscripts denoting place of origin and destination. Due to

[3] Our model, therefore, generalizes the symmetric country model of Felbermayr, Prat, and Schmerer (2011a) to the case of many asymmetric countries.

flow fixed costs, not all firms find it optimal to serve all markets. Serving foreign customers in country j from country i entails iceberg trade costs $\tau_{ij} \geq 1$ (with $\tau_{ii} = 1$ and $\tau_{ij} = \tau_{ji}$) for all i and j. Hence, an intermediate goods producer in country i faces the following inverse demand schedule in country j:

$$p_{ij}[\varphi] = \left(\frac{q_{ij}[\varphi]}{\tau_{ij}}\right)^{-\frac{1}{\sigma}} (P_j)^{\frac{\sigma-1}{\sigma}} \left(\frac{Y_j}{\bar{M}_j^{1-\nu}}\right)^{\frac{1}{\sigma}}, \tag{2}$$

where $P_i = \left(\frac{1}{\bar{M}_i^{1-\nu}} \int_{\omega \in \Omega_i} p[\omega]^{1-\sigma} d\omega\right)^{1/(1-\sigma)}$ is the aggregate price index and $p[\omega]$ is the price of variety ω. We choose the price index of country one as the numéraire, i.e., $P_1 = 1$. Profit maximizing firms allocate sales across markets such that marginal revenues are equalized. This implies $p_{ij}[\varphi] = \tau_{ij} p_{ii}[\varphi]$ for all markets j on which a firm φ based in country i is active. Operating revenues of firms based in country i from sales to market j are therefore equal to $R_{ij}[\varphi] = p_{ij}[\varphi] q_{ij}[\varphi]/\tau_{ij}$. Total revenue of an intermediate input producer based in country i with productivity φ, is then given by:

$$R_i[\varphi] = \sum_{j=1}^{N} I_{ij}[\varphi] q_{ij}[\varphi]^{\frac{\sigma-1}{\sigma}} (P_j)^{\frac{\sigma-1}{\sigma}} \left(\frac{\tau_{ij}^{1-\sigma} Y_j}{\bar{M}_j^{1-\nu}}\right)^{\frac{1}{\sigma}}, \tag{3}$$

where $I_{ij}[\varphi]$ is an indicator function that takes value one if a firm in country i with productivity φ is active on market j and zero otherwise.

3.2 The Labor Market

Firms operate with linear production functions $q_{ij}[\varphi] = \varphi L_{ij}[\varphi]$, where $L_{ij}[\varphi]$ is the level of employment at firm φ in country i for production of goods destined for country j. Our model is in discrete time and all payments are made at the end of each period. At the end of each period, firms and workers are hit by two different types of shocks: With probability χ a job is destroyed due to a match-specific shock and with probability δ firms are forced to leave the market. Assuming independence of these shocks, the actual rate of job destruction is given by $\eta = \delta + \chi - \delta\chi$.

The flow cost of posting a single vacancy is c_i, measured in units of the final good. We denote by $m_i[\theta_i] = \bar{m}_i (\theta_i)^{-\alpha_i}$ the share of posted vacancies v filled each period, where θ_i is the

vacancy-unemployment ratio in country i and $\bar{m}_i$ measures the efficiency of the labor market in country i, while α_i is the elasticity of the matching function. The rate at which unemployed workers find employment is $\theta_i m_i[\theta_i]$.

Each period, an intermediate input producer φ in country i decides (i) about the optimal number of vacancies to post $v_i[\varphi]$, anticipating the bargained wage, and (ii) how to allocate total production over the domestic and the $N-1$ foreign markets. We relegate the market entry problem to section 3.3.

Vacancy posting. The value of an intermediate input producer is given by:

$$\begin{aligned} J_i[\varphi] &= \max_{v_i[\varphi]} \frac{1}{1+r}\Big(R_i[\varphi] - w_i[\varphi] L_i[\varphi] - P_i v_i[\varphi] c_i - P_i \sum_{j=1}^{N} I_{ij}[\varphi] f_{ij} + (1-\delta) J_i'[\varphi]\Big), \quad (4) \\ s.t. \qquad & L_i'[\varphi] = (1-\chi) L_i[\varphi] + m_i[\theta_i] v_i[\varphi], \end{aligned}$$

where r denotes the interest rate, $w_i[\varphi]$ is the wage rate, $J_i'[\varphi]$ is the value of an intermediate input producer next period, and $L_i'[\varphi]$ is firm $\varphi's$ total employment next period. The constraint is the law of motion of employment at the firm level. The first order condition for vacancy posting can be stated as follows:

$$\frac{c_i P_i}{m_i[\theta_i]} = (1-\delta)\frac{\partial J_i'[\varphi]}{\partial L_i'[\varphi]}. \quad (5)$$

It shows that the firm equalizes marginal recruitment costs (given on the left hand side) and the shadow value of labor. Note that firms with different φ's face identical expected recruitment costs; hence, the shadow value of labor is the same across firms, too.

¿From the equalization of marginal revenues across markets, it follows that the shadow value of labor does not depend on the market where the additional output is actually sold. Hence, $\partial J_i[\varphi]/\partial L_i[\varphi] = \partial J_i[\varphi]/\partial L_{ij}[\varphi]$. Differentiating the objective function of the firm (4) with respect to L_{ij} and employing the steady-state condition $\partial J_i[\varphi]/\partial L_{ij}[\varphi] = \partial J_i'[\varphi]/\partial L_{ij}'[\varphi]$ the shadow value of labor is given by:

$$\frac{\partial J_i[\varphi]}{\partial L_i[\varphi]} = \frac{\partial J_i[\varphi]}{\partial L_{ij}[\varphi]} = \frac{1}{r+\eta}\left(\frac{\partial R_i[\varphi]}{\partial L_{ij}[\varphi]} - w_i[\varphi] - \frac{\partial w_i[\varphi]}{\partial L_{ij}[\varphi]} L_{ij}[\varphi]\right). \quad (6)$$

Using (5) we can solve for $\partial R_i[\varphi]/\partial L_{ij}[\varphi]$ and obtain an expression that implicitly determines the optimal pricing behavior of an intermediate input producer:

$$\frac{\partial R_i[\varphi]}{\partial L_{ij}[\varphi]} = w_i[\varphi] + \frac{\partial w_i[\varphi]}{\partial L_{ij}[\varphi]} L_{ij}[\varphi] + \frac{c_i P_i}{m_i[\theta_i]} \left(\frac{r+\eta}{1-\delta}\right). \tag{7}$$

Wage bargaining. The search-and-matching setup developed above is compatible with a number of different assumptions concerning the wage-setting process. We follow Cahuc, Marque, and Wasmer (2008) and assume that wages are bargained before production takes place and that every worker is treated as the marginal worker.[4] In a later section of this paper, we will experiment with the opposite extreme case of a perfectly rigid real wage.

The total surplus from a successful match is split between the employee and the intermediate input producer. The worker's surplus is equal to the difference between the value of being employed at firm φ, i.e., $E_i[\varphi] = (w_i[\varphi] + (1-\eta)E_i[\varphi] + \eta U_i)/(1+r)$ and the value of being unemployed $U_i = \left(b_i \Phi_i P_i + \theta_i m[\theta_i] \bar{E}_i + (1 - \theta_i m_i[\theta_i]) U_i\right)/(1+r)$, where $\bar{E}_i$ is the value of employment at the average firm. The flow value of unemployment in real terms is given by $b_i \Phi_i$ with $b_i \in [0,1]$ and is proportional to the marginal value product of labor at the average domestic firm deflated by the price index: $\Phi_i \equiv \tilde{\varphi}_{ii} p_{ii}[\tilde{\varphi}_{ii}]/P_i$, with $\tilde{\varphi}_{ii}$ denoting the productivity of the average firm. The variable Φ_i will turn out to be a sufficient statistic for determining the role of changing productivity distributions on labor market outcomes. In the following we refer to Φ_i as a measure of aggregate productivity.

Reformulating the expression for $E_i[\varphi]$, the advantage of holding a job at firm φ over searching one can be expressed as:

$$E_i[\varphi] - U_i = (w_i[\varphi] - r U_i)/(r+\eta). \tag{8}$$

The firms's surplus is equal to the marginal increase in the firm's value $\partial J_i[\varphi]/\partial L_{ij}[\varphi]$, which results from the assumption that every worker is treated as the marginal worker. The outcome

[4]This approach is fairly standard in the trade and unemployment literature, see Felbermayr, Prat, and Schmerer (2011a), Cosar, Guner, and Tybout (2011) or Helpman and Itskhoki (2010). Its axiomatic foundation is laid out in Stole and Zwiebel (1996).

of the bargaining process over the division of the surplus follows the "surplus-splitting" rule:

$$(1-\beta_i)\left(E_i\left[\varphi\right]-U_i\right)=\beta_i\frac{\partial J_i\left[\varphi\right]}{\partial L_{ij}\left[\varphi\right]}, \tag{9}$$

where the parameter β_i measures the bargaining power of workers and belongs to $(0,1)$. From (5) and (9) it is already apparent that the value of employment E_i cannot vary across firms so that heterogeneous firms will pay identical wages.[5]

Labor market equilibrium. Substituting (6) and (8) into (9) and using the definition of firms' revenues as given in (3), one obtains a differential equation with solution

$$w_i[\varphi]=\beta_i\left(\frac{\sigma}{\sigma-\beta_i}\right)\frac{\partial R_i[\varphi]}{\partial L_{ij}[\varphi]}+(1-\beta_i)rU_i. \tag{10}$$

Using equation (2) and noting that equalization of marginal costs between markets implies $\frac{\partial R_i[\varphi]}{\partial L_{ij}}=\left(\frac{\sigma-1}{\sigma}\right)\varphi\tau_{ij}^{-1}p_{ij}=\left(\frac{\sigma-1}{\sigma}\right)\varphi p_{ii}$, one obtains the job creation curve:

$$\mathbf{JC}_i\text{:}\quad \frac{w_i}{P_i}=\frac{\sigma-1}{\sigma-\beta_i}\Phi_i-\frac{c_i}{m_i[\theta_i]}\frac{r+\eta}{1-\delta}. \tag{11}$$

The job creation curve slopes downward in θ since a higher degree of labor market tightness makes it more costly to fill vacancies so that a smaller share of the surplus Φ can accrue to the worker. Hence, the real wage falls in θ. Importantly, the wage rate depends only on aggregate variables such as P_i, Φ_i or θ and does, therefore, not vary across firms. The job creation curve depends on Φ_i because more productive firms spend a smaller fraction of their revenue on flow fixed costs f_{ij}, which are denominated in units of the final output good, and a larger fraction on labor. Hence, the reallocation of workers towards more productive firms increases the demand for labor.[6]

[5]Producing wage dispersion across firms in a set-up as the suggested one can be accommodated by assuming heterogeneous workers as in Helpman, Itskhoki, and Redding (2010). However, as we are interested in aggregate unemployment effects, we stick to the simpler framework.

[6]If the costs of vacancy posting c_i as well as the unemployment benefits b_i are indexed to wages, the wage curve becomes vertical at some fixed level of θ_i. The reason is that the workers' outside option as well as their ability to extract rents does not change relative to the wage rate and hence bargaining settles at an unchanged employment level. In this special case, variations in the productivity of the average firm $\tilde{\varphi}_{ii}$ are entirely absorbed by variations in the wage, while the rate of unemployment does not change. If either b_i or c_i are at least partly

Combining equations (2), (7), and (10) shows that the wage rate is given by the sum of the value of non-employment (rU_i) and the rent that the worker can extract from the firm:

$$w_i[\varphi] = rU_i + \frac{\beta_i}{1-\beta_i}\frac{r+\eta}{1-\delta}\frac{c_i P_i}{m_i[\theta]}. \tag{12}$$

Using the expression for U_i, we can write $rU_i = b_i\Phi_i P_i + \theta_i m[\theta_i]\left(\bar{E}_i - U_i\right)$. Using equation (8) and noting that $w_i[\varphi] - rU_i$ is equal for all firms (see equation (12)), one can derive the following wage curve:

$$\mathbf{W}_i: \quad \frac{w_i}{P_i} = b_i\Phi_i + \frac{\beta_i}{1-\beta_i}\frac{c_i}{1-\delta}\left(\frac{r+\eta}{m_i[\theta_i]} + \theta_i\right). \tag{13}$$

The wage curve is an increasing function of θ since workers have more power to hold-up the firm when the labor market is tight and the costs of a break-down of negotiations are high for firms.

Labor market equilibrium is found by interacting the job creation curve and the wage curve; see Figure 1. The following Lemma summarizes a number of equilibrium properties.

Lemma 1 [Labor market equilibrium]

(a) For given aggregate productivity Φ_i, there is a unique labor market equilibrium $\{w_i/P_i, \theta_i\}$ if $\frac{\sigma-1}{\sigma-\beta_i} > b_i$.

(b) A decrease of Φ_i lowers the real wage w_i/P_i and the degree of labor market tightness θ_i.

(c) Wages are constant over firms.

(d) For given Φ_i, variation in institutional parameters b_i, c_i or $\bar{m}_i$ leads to qualitatively equivalent results as regards the degree of labor market tightness θ_i.

The Lemma shows that labor market outcomes can be entirely characterized once aggregate productivity Φ_i is known. That variable summarizes the stance of the entire productivity distribution and the number of available varieties. Trade liberalization can only affect labor markets through this variable. Also, institutional changes in other countries will affect domestic labor markets through Φ_i.

Part (a) in Lemma 1 follows from the fact that the job-creation curve is strictly downward sloping in θ_i, while the wage curve is upward-sloping. An equilibrium exists only if the flow-value

indexed to for example the final output good, unemployment is still affected by trade liberalization and spillovers exist.

of non-employment b_i is smaller than the share of the value of the match that will accrue to the worker. Under the condition stated in (a), any change in Φ_i must have a smaller effect on the flow value of non-employment ($b_i\Phi_i$) than on the flow value of employment $\frac{\sigma-1}{\sigma-\beta_i}\Phi_i$; otherwise, no worker would be willing to seek employment. Hence, a reduction in Φ_i shifts the wage curve (W_i) down by less than the job creation curve (JC_i) . It follows that both the real wage and the degree of labor market tightness fall. This explains part (b) of the Lemma; Figure 1 illustrates. Part (c) implies that workers are paid similarly across firms with different productivity levels. This property of the model is a fairly general feature of Melitz-type models with wage bargaining.[7]

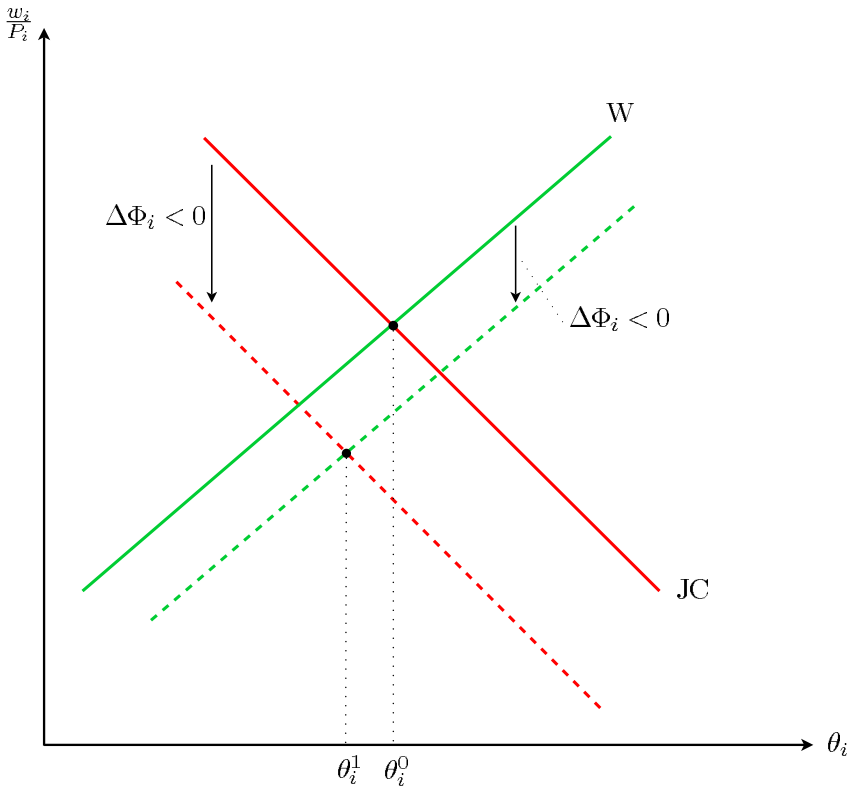

Figure 3: The effect of a fall in Φ_i on labor market tightness.

Part (d) establishes that, whatever the equilibrium value of Φ_i turns out to be, changes in the most relevant labor market institutions – the replacement rate b_i, hiring costs c_i, and the efficiency of the matching process $\bar{m}_i$ – have similar qualitative effects on labor market tightness.[8] This is so because Φ_i does not directly depend on labor market *institutions* b_i, c_i, or

[7]See, e.g., Eckel and Egger (2009) for an analysis of unionized labor markets and Felbermayr, Prat, and Schmerer (2011a) for the case of firm-level collective bargaining in the presence of search frictions.

[8]We have $\partial\theta_i/\partial b_i < 0, \partial\theta_i/\partial c_i < 0$, and $\partial\theta_i/\partial\bar{m}_i > 0$.

$\bar{m}_i$ but only on labor market *outcomes* such as the real wage or the rate of unemployment.

3.3 Entry- and Export Decisions of Firms

Next, we have to pin down Φ_i for all countries. This is done by combining two sets of equations: conditions that describe the selection of firms into different markets according to their productivity levels, and conditions that determine the number of firms that enter into existence each period. These equations determine the productivity of the average firm $\tilde{\varphi}_{ii}$ and the price level. However, unlike in perfectly symmetric setups of Melitz-type models, we need to know labor market outcomes to pin down these variables.

There is an infinite number of potential firms which can enter the market after paying a fixed and sunk entry cost f^e, measured in terms of the final consumption good. After entering, they draw their productivity φ from a known distribution with p.d.f. $g[\varphi]$ and c.d.f. $G[\varphi]$. The productivity stays the same as long as the firm exists. Only firms which draw a φ favorable enough to make non-negative profits will start production and engage into sales in one or several markets.

Entry into markets. A firm with productivity φ located in country i will engage in market j if the expected discounted operating profits exceed costs. Hence, the firm recruits workers with the aim to produce output for market j if and only if

$$\begin{aligned}\Pi_{ij}[\varphi] &= \sum_{t=1}^{\infty}\left(\frac{1-\delta}{1+r}\right)^t \pi_{ij}[\varphi] - \frac{P_i c_i}{m_i[\theta_i]} L_{ij}[\varphi] - P_i f_{ij} \\ &= \frac{1-\delta}{r+\delta}\pi_{ij}[\varphi] - \frac{P_i c_i}{m_i[\theta_i]} L_{ij}[\varphi] - P_i f_{ij} \geq 0. \end{aligned} \tag{14}$$

The first term in expression (14) is the discounted flow of operating profits that a firm in country i with productivity φ obtains from sales in country j. The second term describes the costs of recruiting, which arise before production can start.

The flow of profits from sales to market j is given by

$$\pi_{ij}[\varphi] = R_{ij}[\varphi] - \left(w_i + P_i c_i \frac{\chi}{m_i[\theta_i]}\right) L_{ij}[\varphi] - P_i f_{ij}, \tag{15}$$

which are revenues in country j of a firm based in country i with productivity φ, $R_{ij}[\varphi]$, minus total costs of employing the necessary amount of workers L_{ij} to achieve those revenues including the costs to replace the workers who quit (at exogenous rate χ) and the fixed costs (in units of the final good) to maintain the presence in market j.[9]

We may characterize the productivity level which makes a firm indifferent between operating in a market or not by solving $\Pi_{ij}\left[\varphi_{ij}^*\right] = 0$. This gives the *zero cutoff-profit condition*

$$\frac{1-\delta}{r+\delta}\pi_{ij}\left[\varphi_{ij}^*\right] = \frac{P_i c_i}{m_i\left[\theta_i\right]} L_{ij}\left[\varphi_{ij}^*\right] + P_i f_{ij}. \tag{16}$$

For the marginal firm φ_{ij}^* the discounted value of future operating profits has to be large enough to cover upfront costs. Empirical evidence strongly supports the view that only the most productive firms select into foreign markets. Hence, we focus on parameter values where $\varphi_{ij}^* > \varphi_{ii}^*$ for all i, j. The ex ante probability of successful entry into the home market i is $(1 - G[\varphi_{ii}^*])$, whereas the ex ante probability of exporting to country j conditional on successful entry is $\varrho_{ij} = (1 - G\left[\varphi_{ij}^*\right])/(1 - G\left[\varphi_{ii}^*\right])$.

Entry into existence. Following Melitz (2003), we define average productivity of firms from country i serving foreign market j as $\tilde{\varphi}_{ij} = \left((1 - G[\varphi_{ij}^*])^{-1} \int_{\varphi_{ij}^*}^{\infty} (\varphi_i)^{\sigma-1} g[\varphi_i] d\varphi_i\right)^{1/(\sigma-1)}$. Based on this definition we can write down the *free entry condition* as:

$$f^e P_i = \sum_{j=1}^{N} \left(1 - G[\varphi_{ij}^*]\right) \left(\frac{1-\delta}{r+\delta}\pi_{ij}[\tilde{\varphi}_{ij}] - \frac{P_i c_i}{m_i[\theta_i]} L_{ij}[\tilde{\varphi}_{ij}] - P_i f_{ij}\right), \tag{17}$$

where we have the costs of entering a market on the left hand side and the expected profits on the right hand side. The profits of the firm are not yet known at the time of the entry-decision because the productivity level is unknown. With probability $1 - G[\varphi_{ii}^*]$ the productivity will be high enough to make production profitable in the home country i. With probability $1 - G[\varphi_{ij}^*]$ the productivity will be high enough so that even exporting to country j is profitable. The term in brackets indicates how much a firm will earn in these cases.

[9]Note that we assume that the domestic final output good is used for foreign market fixed costs. One could alternatively posit that the foreign final output good is used for foreign fixed costs. Another option would be to assume free trade in the final output good so that $P_i = 1$ in all countries. This choice has no major qualitative implications for our findings.

Equality in equation (17) is assured by the entry of new firms. As long as average profits exceed the entry cost, new firms will enter the market, increasing competition, thereby driving down profits until they have reached the entry cost (and vice versa if profits are too low). The mass of available varieties in country i is given by $\bar{M}_i = \sum_h \varrho_{hi} M_h$, where M_h is the mass of active producers in country h.

3.4 Stationarity, market clearing conditions, and general equilibrium

As usual, we focus on a situation where *flows into and out of unemployment* are of equal size, hence $\eta(1-u_i) = \theta_i m_i[\theta_i] u_i$. This provides us with a one-to-one mapping between labor market tightness and the stationary rate of unemployment. Similarly, we require that the *flow into the pool of operating firms* is equal to the flow out of this pool; hence, $(1-\delta)(1-G[\varphi_{ii}^*]) M_i^e = \delta M_i$, where M_i^e is the total mass of firms that attempt entry (and therefore pay the entry fee f^e).

The *labor market clearing condition* is given by $L_i^e = (1-u_i)L_i$, where L_i^e is aggregate employment and L_i is labor supply in country i. The mass of active domestic firms adjusts so that the labor market clears, hence $M_i = L_i^e / (\sum_{j=1}^N \varrho_{ij} L_{ij}[\tilde{\varphi}_{ij}])$.

Total spending on the aggregate output good, i.e., *total nominal income*, is defined as the sum of revenues generated by intermediate goods producing firms from sales on the domestic and export markets. Using the free entry condition given in equation (17), the expression for $\pi_{ij}[\varphi]$ given in equation (15), the definition for the ex ante probability of exporting to country j conditional on successful entry $\varrho_{ij} = (1-G\left[\varphi_{ij}^*\right])/(1-G[\varphi_{ii}^*])$, the distribution of workers across markets $L_i^e = M_i \sum_{j=1}^N \varrho_{ij} L_{ij}[\tilde{\varphi}_{ij}]$, and summing over all firms M_i, we can solve for aggregate income:

$$\sum_{j=1}^{N} M_i \varrho_{ij} R_{ij}[\tilde{\varphi}] = w_i L_i^e + \frac{P_i M_i}{1-\delta}\left((1+r)\sum_j \varrho_{ij} f_{ij} + \frac{r+\delta}{1-G[\tilde{\varphi}_{ii}^*]} f^e\right) + \frac{\eta+r}{1-\delta} L_i^e \frac{P_i c_i}{m_i[\theta_i]}, \quad (18)$$

which is the sum of payments to employed workers (aggregate consumption expenditure), on flow fixed costs f_{ij}, on appropriately discounted up-front investments f^e, and on search costs.[10]

[10]Note that we assume that the final output good is non-traded. Alternatively, one could assume that Y is freely tradable across countries. This choice would neither be more realistic, nor would it give rise to major analytical simplifications. Additionally, the results are hardly affected by assuming a freely tradable final good.

Intermediate inputs are traded across countries. In equilibrium every country maintains multilateral (though not bilateral) *trade balance* so that the total aggregate value of imports is equal to the total aggregate value of exports.

4 Model calibration

Both the Mortensen-Pissarides and the Melitz models have been calibrated extensively in the literature so that we can follow the standard practice here. We calibrate the model for three countries (hence, $i = 1, 2, 3$, $j = 1, 2, 3$ and $N = 3$), which is the minimum number of countries in order to capture trade diversion effects and discuss the role of geography. In the benchmark case all three countries are completely symmetric in the initial steady-state and their equilibrium allocations replicate key empirical moments of the United States. We set $\nu = 0$ (thereby ruling out external economies of scale) in order to avoid a mechanic link between country size and unemployment.[11] Time is discrete and the time interval is set to one month.

Following the literature, we assume that firms sample their productivity from a Pareto distribution, so that the p.d.f. is $g(\varphi) = \gamma\bar{\varphi}^{\gamma}\varphi^{-(1+\gamma)}$.[12] The shape parameter γ measures the rate of decay of the sampling distribution and $\bar{\varphi} > 0$ is the minimum possible value of φ. We follow Bernard, Redding, and Schott (2007) and set γ equal to 3.4. Without loss of generality, we may normalize $\bar{\varphi} = 0.5$. Burstein and Vogel (2011) show that $\gamma \to \sigma - 1$ effectively closes down the selection channel so that the Melitz (2003) model nests the Krugman (1980) model.

The matching function is Cobb-Douglas $\bar{m}(\theta_i)^{-\alpha_i}$. We follow the standard practice and set $\alpha_i = 0.5$. In the absence of well-established estimates, we set the bargaining power $\beta_i = \alpha_i$. To calibrate the scale parameter $\bar{m}$, we use empirical estimates of the job finding rate and labor market tightness. Constant returns to scale of the matching function implies that the equilibrium tightness must be equal to the ratio of these two rates. Shimer (2005) estimates the monthly rate at which workers find a job to be equal to 0.45. Hall (2005) finds an average

[11] We also investigated the effects of changes in ν. They do not affect any of our qualitative results. Results are available upon request.

[12] See for example Axtell (2001); Helpman, Melitz, and Yeaple (2004); or Bernard, Redding, and Schott (2007). The assumption of Pareto distributed productivities is justified by the observation that the log-density of firms's log-sizes is well approximated by an affine function.

ratio of vacancies to unemployed workers of 0.539 over the period going from 2000 to 2002. Accordingly, we match an equilibrium tightness of 0.5 by setting the monthly job filling rate to 0.9. Reinserting these values into the matching function, we find that $\bar{m} = 0.636$.

Job separations occur either because the firm leaves the market or because the match itself is destroyed. We consider that the first type of shock arrives at a Poisson rate of 0.916% per month. This implies that the annual gross rate of firm turnover is equal to 22%, as suggested by the estimates in Bartelsman, Haltiwanger, and Scarpetta (2004). The match-specific shocks account for the job separations which are left unexplained by the firm-specific shock. Given that Shimer (2005) estimates the monthly rate of job separation to be 0.034, it follows that the rate of arrival of match-specific shocks χ should be equal to 0.025 per month.

We set the interest rate to 4% per year. In order to calibrate the value of non-market activity, we follow Shimer (2005) and set $b_i = 0.4$ for all i in the benchmark to match an earnings replacement ratio close to 40%. The cost of posting a vacancy, c_i, is set 50% above the vacancy filling rate for all three countries. Given that the equilibrium wage is around $w_i = 1.137$, this value yields an average recruitment cost of around 5.7 weeks of workers' earnings, as suggested by empirical estimates.

We choose variable trade costs τ_{ij} equal to 1.3 for all country-pairs ij in the benchmark equilibrium, following Ghironi and Melitz (2005). Given the Pareto distribution for firm productivities, the share of firms that export is

$$\varrho_{ij} = \tau_{ij}^{-\gamma} \left(\frac{P_j}{P_i} \right)^{\gamma} \left(\frac{R_j f_{ii}}{R_i f_{ij}} \right)^{\frac{\gamma}{1-\sigma}}. \tag{19}$$

That number is put at about 21% by Bernard, Eaton, Jensen, and Kortum (2003). Together with $\tau_{ij} = 1.3$ for all country-pairs ij and assuming a symmetric benchmark equilibrium, this pins down the ratio f_{ij}/f_{ii} at about 1.7. We use the values of entry costs, f^e, and the flow fixed costs, f_{ij}, to match the following two moments. First, we ensure that the equilibrium tightness $\theta_i = 0.5$ for all countries in the benchmark equilibrium. Second, we target an average firm size equal to 21.8 employees, as estimated by Axtell (2001). The calibrated entry costs are equivalent to 2.82 years of income per capita.

Table 1 summarizes the parameterization.

5 Interdependence of labor market outcomes

In this section we study the interdependencies of labor market outcomes. We first discuss how domestic institutions impact outcomes at home and in trading partner countries. Afterwards we investigate how the size of the involved countries, their geography, as well as real wage flexibility affect the magnitude of the spillovers.

5.1 How domestic institutions impact outcomes world-wide

In this subsection we analyze the effects of higher unemployment benefits in country 1 (at home) on domestic and foreign (countries 2 and 3's) unemployment rates, keeping countries identical in all other respects.[13] We vary b_1 in the interval $[0.4, 0.8]$ and hold unemployment benefits for countries 2 and 3 constant at the benchmark value of 0.4. Similarly, we consider iceberg trade costs from 0 to 60%.[14] The main insights from these experiments are summarized in Results 1a to 1c and visualized in Figure 4. The left-hand diagram in Figure 4 shows the unemployment rate in country 1 for various values of trade costs on the x-axis (equal between all countries) and unemployment benefits in country 1 on the y-axis. The right-hand diagram shows the unemployment rate in country 2 for various values of trade costs on the x-axis and unemployment benefits in country 1 on the y-axis.

Result 1a [Labor market reform]

If a country increases its unemployment benefits, then its unemployment rate goes up.

Result 1a is a standard result in a Pissarides (2000) setup. It is also in line with empirical evidence; see Bassanini and Duval (2006).

Result 1b [Globalization and labor markets]

[13] We pay particular attention to cross-country differences in unemployment benefits as they are easily observable in the data, exhibit substantial variation across countries, and are shown to consistently explain unemployment rates in empirical research; see, e.g., Bassanini and Duval (2006). Moreover, we know that the model reacts similarly to changes in search costs c_i or the search technology $\bar{m}_i$ (see Lemma 1).

[14] Trade costs are in percent, i.e., $\tau(\%) = (\tau - 1) \times 100$.

Table 1: Base-line calibration of parameter values

Parameter	Description	Value	Source
r	Discount rate	0.33%	4% annual discount rate
ν	Parameter of external scale economies	0	Blanchard and Giavazzi (2003)
σ	Elasticity of substitution	3.8	Bernard, Redding, Schott (2007)
b_i	Unemployment benefits	0.4	Bassanini and Duval (2006)
$\bar{m}$	Efficiency of matching function	0.636	Job finding rate=0.45; Shimer (2005) and Hall (2005)
α	Elasticity of the matching function	0.5	Hosios (1990)
β	Bargaining power	0.5	Hosios (1990)
δ	Rate of firm exit	0.91%	Firm turnover rate=1.8%; Bartelsmann, Haltiwanger and Scarpetta (2004)
χ_i	Rate of match-specific separation	2.5%	Job separation rate=3.4 (Shimer (2005))
$\bar{\varphi}$	Minimum value of productivity	0.5	Arbitrary.
γ	Shape of Pareto Distribution	3.4	Bernard, Redding, Schott (2007)
c	Cost of posting a vacancy	1	To match $\theta = 0.5$; Hall (2005)
f^e	Fixed entry cost	39.57	To match $\theta = 0.5$; Hall (2005)
f	Fixed cost of production	0.116	Average firm size = 21.8 (Axtell (2001))
f^x	Fixed foreign market access costs	0.197	Bernard, Eaton, Jensen and Kortum (2003)
τ	Iceberg trade costs	1.3	Ghironi and Melitz (2005)
L_i	Size of population	1	Size normalization
P_1	Numéraire	1	Normalization
N	Number of countries	3	Allows for direct and indirect spillovers

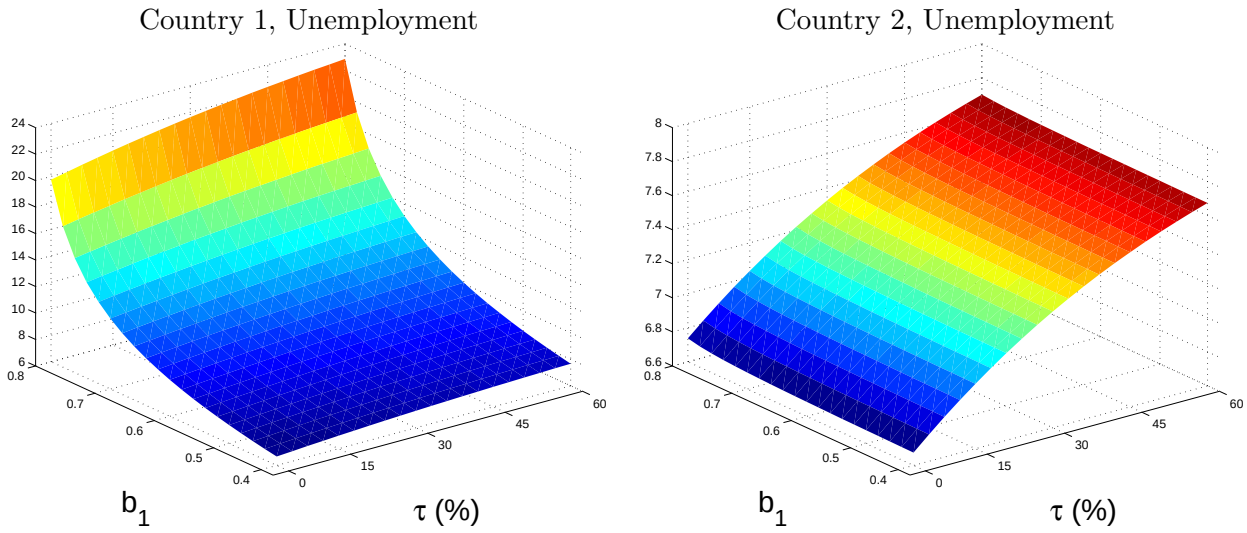

Figure 4: Country 1 labor market regulation and unemployment in countries 1 and 2 (=3). [Rate of unemployment on the vertical axis.]

Trade liberalization leads to lower unemployment in all countries.

Result 1b extends the theoretical findings in Felbermayr, Prat, and Schmerer (2011a) to asymmetric countries. As shown in Figure 4, in all countries, unemployment is lowest for minimum values of trade costs and unemployment benefits of country 1. If trade costs decrease from 60% to 0%, unemployment in all countries falls from about 8% to 6.5%. So, trade liberalization can have a very substantial impact on the long-run rate of structural unemployment.

Result 1b is driven by the change in relative prices and the selection of firms. Trade liberalization modeled by lower iceberg trade costs results in lower import prices. As a consequence, the price index falls and real income increases in all countries. Further, inefficient firms in all countries face stronger competition by efficient foreign firms, making it impossible for them to cover flow fixed costs. Simultaneously, the most efficient domestic firms expand due to increased sales abroad. As a consequence, the average domestic firm's productivity $\tilde{\varphi}_{ii}$ goes up. It has larger sales and a lower price, $p_{ii}\left[\tilde{\varphi}_{ii}\right]$, but – due to $\sigma > 1$, the price falls by less than productivity increases and $\tilde{\varphi}_{ii}p_{ii}\left[\tilde{\varphi}_{ii}\right]$ goes up. The change in the price index and the selection of firms leads to an increase of $\Phi_i \equiv \tilde{\varphi}_{ii}p_{ii}\left[\tilde{\varphi}_{ii}\right]/P_i$ in all countries, leading to lower unemployment in all countries. This result is in line with aggregate empirical evidence presented by Dutt, Mitra, and Ranjan (2009), or Felbermayr, Prat, and Schmerer (2011b).

Result 1c [Institutional spillovers]

If one country increases its unemployment benefits, then, in all other countries, unemployment rises. The size of the spillover effect is about two orders of magnitude smaller than the effect in the originating country.

Increasing b_1 affects Φ_2 and Φ_3 and therefore unemployment in countries 1 and 2 by the relative-price effect and the selection effect. First, since country 1 spends part of its income on foreign varieties, increased unemployment in that country reduces demand for goods from countries 2 and 3, thereby lowering those countries' exports and export prices, which tends to increase the unemployment rate. The increase in the workers' outside option pushes up the real wage in country 1, the prices of country 1's varieties go up relative to varieties from countries 2 or 3. Moreover, as employment contracts, the number of firms in country 1 and hence the number of varieties produced falls. This endows firms in countries 2 and 3 with a better competitive stance: Residual demand for each firm is higher, which tends to decrease unemployment in countries 2 and 3. Second, the change in demand harms the most productive firms (i.e., the exporters); hence, average productivity goes down and Φ_2 and Φ_3 fall. Lower competition implies that unproductive firms that were too unproductive to survive before the change in b_1, now survive. This again drives down Φ_2 and Φ_3 and lowers incentives to post vacancies, increasing unemployment. Overall the increase in b_1 increases unemployment in all countries.

This finding is robust to alternative calibrations. However, our quantitative exercise shows that the spillover effects are fairly small. The own effect of inefficient labor market institutions in country 1 is by about two magnitudes stronger than the effect on the unemployment rates in countries 2 and 3 (see for example Figure 5). This is puzzling given the empirical evidence that spillovers are about a tenth of the effect in the originating country. Hence, even when allowing for both the relative-price effect and the selection effect a sensible calibration of the theoretical model does not produce spillovers in line with empirical evidence.

This result may depend on our assumption of countries of equal size and geography. We therefore investigate next the effects of country size and geography on the magnitude of labor market spillovers.

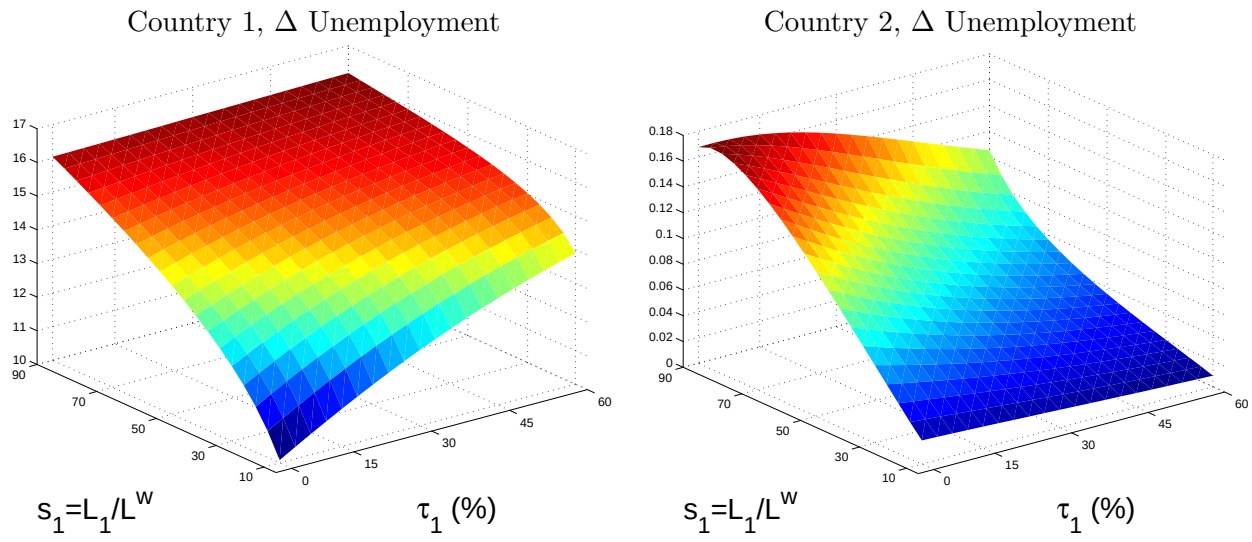

Figure 5: Change in unemployment [on the vertical axis] as a function of centrality and size of country 1 for a given change of b_1 from 0.4 to 0.8.

5.2 Country size

The only channel of transmission of institutional changes in country 1 to labor market outcomes in countries 2 and 3 is trade in intermediate goods. Since our model implies a straight-forward gravity-type link between trade costs, country sizes, and bilateral trade volumes, it is natural to study the implications of these variables on the strength of institutional spillovers.

First, we study how the size of country 1 affects spillovers. We measure country size in terms of population, as income is endogenous in our model. More precisely, we fix the world population $L^w = \sum_{i=1}^{3} L_i$, and then change country 1's share of world population from 10% to 90%. The remaining population is distributed equally between countries 2 and 3.

Result 2 [Relative size and spillovers]

The higher the relative size of country 1, the stronger is the increase in unemployment rates in all countries following a rise in country 1's unemployment benefits. However, the spillover effects are still very small when compared to the effects in the originating country.

For illustration see the variation of country size on the $y-$axis in figure 5. The variation of τ_1 on the $x-$axis is discussed in Result 3. The figure shows the absolute change of the unemployment rates, Δu_1 (left-hand diagram) and $\Delta u_2 = \Delta u_3$ (right-hand diagram) generated

by a given change of b_1 (from 0.4 to 0.8). For $\tau_1 = 30\%$ and $s_i = 0.33$, an increase of b_1 from 0.4 to 0.8 moves u_1 up by about 15 percentage points in country 1 and by about 0.03 percentage points in countries 2 and 3. This effect can also be read off Figure 4 by comparing unemployment rates at $\tau = 30\%$ for $b_1 = 0.4$ and $b_1 = 0.8$.

In line with Hypotheses 1b and 1c, the change in unemployment is positive for all countries. The new insight from Figure 5 is that country-size affects the size of spillovers. At the benchmark value of $\tau = 30\%$, moving s_1 from 0.1 to 0.9 increases the gradient of unemployment with respect to b_1 from about 12 percentage points to 16 in country 1 and from virtually zero to about 0.14 percentage points in countries 2 and 3. The logic for this result is straight-forward. When s_1 is very large, demand of firms in all countries depends a lot on country 1's income. Hence, variations in b_1 have strong implications not only for country 1 but for the entire world. If s_1 is very small, the variation in b_1 has implications only for a very small fraction of global demand and therefore has little effect on unemployment rates world-wide.

Besides this change in the absolute size of the spillovers, the relative size of the spillovers with respect to the effect of the originating country stays small. It is smallest for very small countries to about a hundredth of the effect for $s_1 = 0.9$. Hence, country size does not help to resolve the puzzling small relative spillover effects. Even for very extreme size differences, our predictions from the calibrated model differ by an order of magnitude from the empirical evidence.

5.3 Geography

In this subsection we study a second conditioning variable for spillovers, the role of geography. We therefore change the *centrality* of country 1, i.e., we vary its multilateral, or overall, degree of openness. Assuming symmetric bilateral trade costs between all countries ($\tau_{jk} = \tau_{kj}$ for all j, k) and treating countries 2 and 3 as identical ($\tau_{j1} = \tau_{1j} = \tau_1$ for all $j \neq 1$), we solve the model for different degrees of centrality of country 1 (i.e., we vary τ_1) while keeping trade costs between countries 2 and 3 (τ_{jk} for all $j \neq 1, k \neq 1$) constant. The outcome is summarized in the following result and visualized in Figure 5.

Result 3 [Geography and spillovers]

For a higher degree of centrality of country 1, a given rise in country 1's unemployment benefits yields a smaller unemployment increase in country 1 and a larger increase in countries 2 and 3. However, the spillover effects are still very small when compared to the effects in the originating country.

For illustration see the variation of τ_1 on the $x-$axis in Figure 5, where lower values of τ_1 indicate higher centrality of country 1. It can be seen that a higher degree of centrality of country 1 dampens the increase in the unemployment rate in country 1 but strengthens the increase in countries 2 and 3. We see that the increase in b_1 increases unemployment in country 1 by about 13 percent when $\tau_1 = 0$ and by about 16 percentage points when $\tau_1 = 0.6$. Hence, the more central a country is, the lower are the unemployment costs of its own bad institutions. Trade partners, however, suffer more as a decrease in τ_1 drives up the change in the unemployment rate.

The intuition for Result 3 is straightforward. If country 1 is more central, it trades more with countries 2 and 3. If country 1 has no access to international markets ($\tau_1 \to \infty$), lower *domestic* demand for country 1's products due to higher unemployment in that country would be tantamount to lower *total* demand, so that the adverse labor market implications are most severe. In the other extreme, where $\tau_1 = 0$, domestic demand only accounts for a fraction of total demand faced by country 1's firms. Therefore, the resulting increase in the unemployment rate is smaller, as part of the costs is born by countries 2 and 3 due to lower export demand. That logic holds in reverse for countries 2 and 3 which rely more on country 1's demand when τ_1 is lower.

However, quantitatively, the effect is fairly small. Hence, geography is also not able to align the theoretical predictions with the empirical ones. The difficulties of our theoretical model to mimic the empirically observed size of labor market spillovers is similar to the difficulties of the standard search-and-matching model to explain the business-cycle fluctuations of unemployment (see Shimer (2005)). Motivated by this fact, we will try to solve this puzzling result by following the suggestions in the former literature. There the most prominent suggestion to explain unemployment fluctuations over the business-cylce is to assume rigid wages (see, e.g., Hall (2005a)).

5.4 Real wage rigidity

In this subsection we contrast the analysis of earlier subsections, where wages are fully flexible (i.e., renegotiable each period), with the opposite extreme assumption of perfect real wage rigidity. The lack of adjustment in prices naturally increases the scope of adjustment in quantities. Hence, real wage rigidity should increase spillovers in terms of unemployment rates. Comparing the cases of flexible bargaining with rigid real wages spans the interval in which the 'true' size of spillovers lies.[15]

When real wages are rigid, the wage curve (13) is replaced by the requirement that $w_i/P_i = \bar{\omega}_i$. We recalibrate the model such that our choice $\bar{\omega}_i$ reproduces the unemployment rates, firm and job turnover rates, export penetration rates, and the average firms sizes as shown in Table 1. All external parameters are the same as in the earlier calibration.[16] Since the replacement rate b_i appears only in the now redundant wage curve, we vary the cost of vacancy creation c_i over the interval $[1, 1.3]$.

Figure 6 reproduces Figure 5 for the new scenario (c_1 rather than b_1 is changed) and under the assumption of rigid real wages. When c_1 grows from 1 to 1.3, the unemployment rate in country 1 moves up by about 0.8 to 2.2 percentage points, depending, as before, on the relative size of country 1 and on its geographical location relative to its trading partners. The spillovers to countries 2 and 3 (again treated symmetric) are now much more sizeable than before and vary between 0 and 1 percentage points. The model predicts that the strength of spillovers is up to 45% of the effect in the reforming country. This is in strong contrast to our earlier results for individually bargained wages (Figure 5). The effect is larger than the empirically predicted size of spillovers of about a tenth. Hence, while perfect real wage rigidity leads to excessively strong spillovers, search-and-matching labor market frictions with flexibly bargained wages lead to insufficiently small effects. Hence, combining search-and-matching labor market frictions with a more rigid wage curve than resulting from flexible wage bargaining is able to cope with the

[15]Note that non-perfect real wage rigidity could be easily implemented in the search-and-matching framework. With non-perfect real wage rigidity, the model can also be solved with homogeneous firms. In a model with perfectly rigid real wages or binding minimum wages, heterogeneity of firms is crucial to generate positive unemployment rates in all countries.

[16]The structure of the model implies that, in the baseline equilibrium, the value of $\bar{\omega}_i$ will be identical to the real wage that results under individual bargaining.

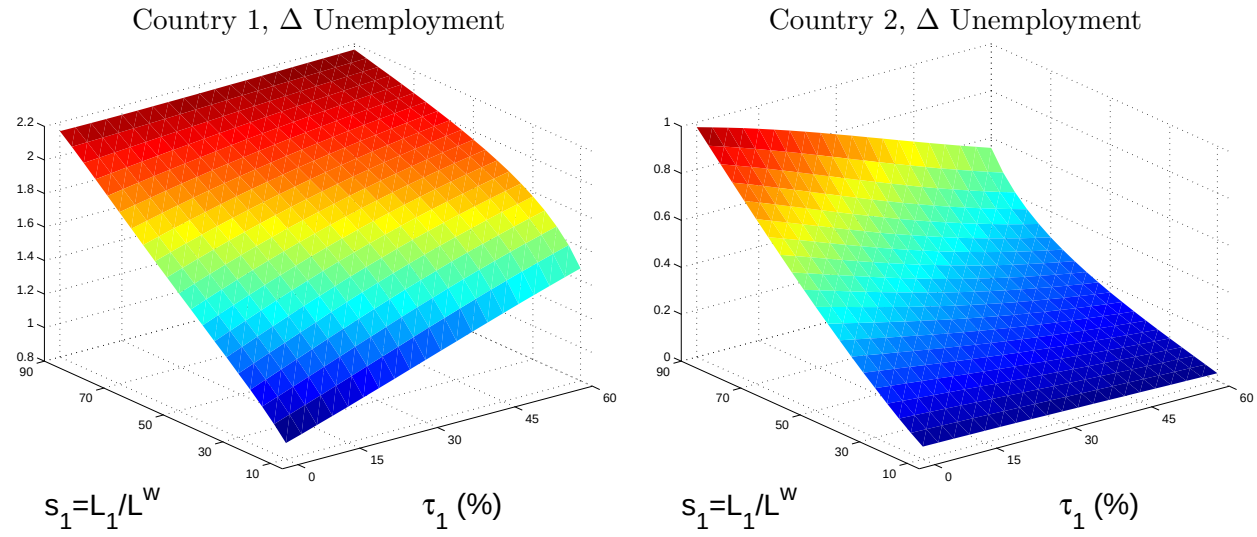

Figure 6: Change in unemployment [on the vertical axis] as a function of centrality and size of country 1 for a given increase of country 1's search costs from 1 to 1.3 under *perfect real wage rigidity*.

empirical facts.

To make sure that this difference does not come from our change in the experiment (changing c_1 instead of b_1), we repeat the same exercise with flexible wages. Figure 7 confirms that the change in results indeed stems from wage rigidity. Result 4 summarizes these findings.

Result 4 [Real wage rigidity and spillovers]

The size of international spillover effects depends on the degree of wage rigidity. When wages are bargained flexibly, an increase in country 1's search costs has small effects on country 2 and 3's unemployment rates. When real wages are perfectly rigid, the same scenario leads to an increase in unemployment in countries 2 and 3 of up to 45% of the effect in country 1.

6 Robustness

One could object that our results are sensitive to the details of the calibration. Hence, this robustness section provides a sensitivity analysis with respect to the important parameters potentially affecting the size of the spillovers. Specifically, we will investigate the role of firm-level heterogeneity γ, the role of the elasticity of substitution σ, the effect of external economies of scale ν, and the role of the relative size of fixed costs of exporting to domestic fixed costs f^x/f.

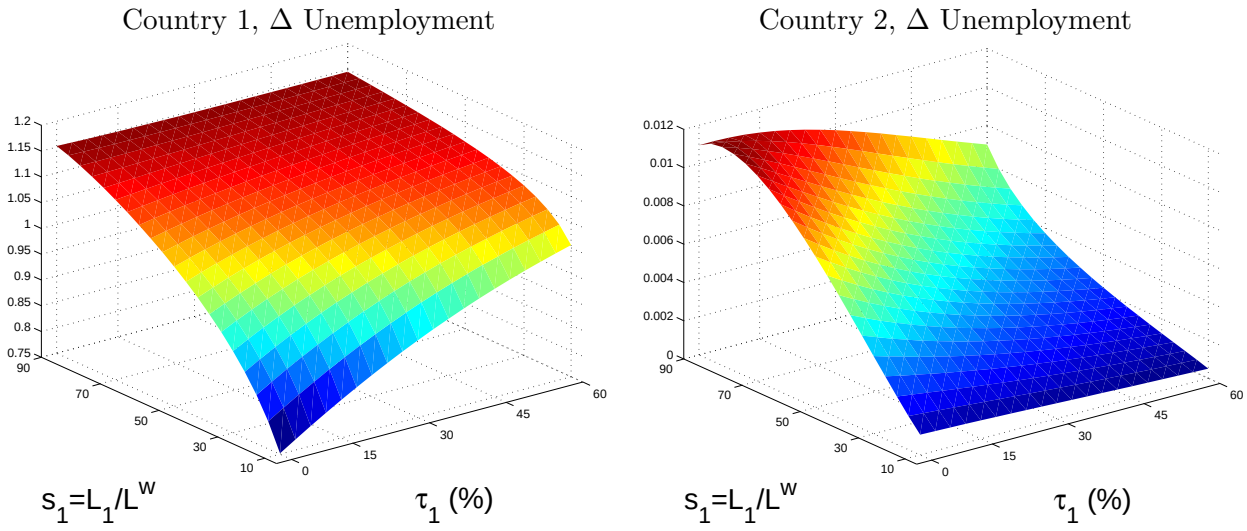

Figure 7: Change in unemployment [on the vertical axis] as a function of centrality and size of country 1 for a given increase of country 1's search costs from 1 to 1.3 *when wages are bargained individually.*

Table 2 reports changes in the unemployment rate for different trade costs τ when country 1's generosity of unemployment insurance goes up from $b_1 = 0.4$ to 0.8. As in our baseline results wages are assumed to be bargained in all our robustness exercises.

Table 2: Robustness results

		τ=0%		τ=30%		τ=60%	
		Country		Country		Country	
		1	2	1	2	1	2
γ	3.4	13.07	0.06	14.34	0.04	15.19	0.03
	6.5	12.61	0.03	13.57	0.01	13.86	0.00
	10.0	12.32	0.01	12.90	0.00	12.97	0.00
f^x/f	1.0	13.64	0.06	14.74	0.04	15.43	0.02
	1.7	12.98	0.06	14.29	0.04	15.16	0.03
	2.4	12.74	0.06	14.16	0.04	15.10	0.03
σ	3.8	13.07	0.06	14.34	0.04	15.19	0.03
	6.7	7.60	0.04	8.32	0.03	8.82	0.02
	10.0	6.70	0.04	7.33	0.03	7.77	0.02
ν	0.00	13.07	0.06	14.34	0.04	15.19	0.03
	0.47	15.41	0.09	17.07	0.06	18.16	0.04
	0.99	20.71	0.18	23.49	0.14	25.35	0.09

Notes: Change in unemployment as a function of trade costs (in the columns) and the shape parameter of the Pareto distribution (γ), the degree of external economies of scale (ν), the elasticity of substitution (σ), and the ratio of fixed foreign market access costs to fixed costs of production (f^x/f) in the rows for a given change of b_1 from 0.4 to 0.8 for countries 1 and 2.

We demonstrate the role of firm heterogeneity by changing γ, the shape parameter of the Pareto distribution. We vary γ between 3.4 and 10. A shape parameter of the Pareto distribution of $\gamma = 3.8$ with a lower bound of $\bar{\gamma} = 0.5$ implies a standard deviation of 0.260, whereas a $\gamma = 10$ implies a standard deviation of 0.062.[17] Hence, a higher value of γ is associated with less firm heterogeneity; it is, however, also associated with a lower mean of the productivity distribution. As can be seen from Table 2, the more equal firms are concerning their productivity, i.e. with higher γ, the less changes in unemployment benefits affect unemployment in both, the country where the change occurs and the trading partner country. This is so because changes in unemployment benefits do not strongly affect average productivity when selection is unimportant (i.e., γ is high). For the trading partner, a second fact is important. If firms are nearly homogeneous, then only few firms are productive enough to incur the fixed costs for both, the home market and the foreign market. Hence, there is less trade when firms are more homogeneous. With a $\gamma = 10$ and trade costs of $\tau = 1.6$, the spillover nearly vanishes, as hardly any firms from country 1 serve the foreign customers.[18] More importantly, firm-level heterogeneity provides an additional channel for positive labor market spillovers between countries. This is well in line with Egger, Egger, and Markusen (2012). However, even with a very large degree of firm-level heterogeneity, the spillover effects are very small in magnitudes. Hence, firm-level heterogeneity alone is not able to explain the *Shimer-puzzle of international trade*.

Equally important for the number of exporting firms is the ratio of fixed costs of exporting to fixed costs of production, (f^x/f). Increasing this ratio leads to a lower share of exporting firms. As with increasing γ, changes in labor market institutions then have a smaller effect on average productivity, decreasing the effects on unemployment in all countries. Additionally, the spillover is lower with a higher f^x/f ratio. More importantly, even when assuming $f^x = f$, so that all active firms export, the spillovers remain small and cannot explain the empirically observed magnitude.

[17] Note that for a Pareto distribution, the standard deviation is given by $\frac{\bar{\gamma}}{\gamma-1}\sqrt{\frac{\gamma}{\gamma-2}}$. Further, we assume that $\gamma > \sigma - 1$ so that the variance of log productivity is finite.

[18] Remember that, in the Melitz model with Pareto-distributed productivity, the freeness of trade is given by $\tau^{-\gamma}$.

Our next robustness check is with respect to the elasticity of substitution σ. This parameter has crucial implications for the role of the relative-price effect and the selection effect. We therefore vary σ between 3.8 and 10.[19] Our main results are that a higher elasticity of substitution leads to smaller increases in unemployment rates in all countries following a rise of country 1's unemployment benefits. A higher σ more strongly insulates firms from foreign competition as exports are proportional to $\tau^{1-\sigma}$.[20] For given levels of trade costs, this term becomes smaller with increases in σ and thus bilateral trade flows become lower. As a consequence, countries depend less on global demand and more on domestic demand. This has two implications. On the one hand, the country where the labor market shock occurs is hit harder as it cannot spillover part of the negative shock to other countries, on the other hand trading partners are less affected due to lower trade volumes. Hence, in country 1, the effect is stronger with higher σ, while it is weaker in the rest of the world.

Note further that, when $\nu < 1$, the monopolistic competition model exhibits a monopoly distortion that leads to excess entry. The strength of this distortion, however, depends on σ (big if σ is small). So, as we increase σ, we reduce the distortion, which has positive effects on the level of aggregate productivity and hence labor market outcomes. This explains why the increase in unemployment is smaller in country 1 for higher σ's. Overall, the smaller changes in unemployment of country 1 as well as the lower trade volumes for higher values of σ imply that adverse spillovers from country 1 to the rest of the world should decrease with rising σ. In a world with increased product differentiation (σ falls), cross-country interdependencies become more pronounced. However, as can be seen from Table 2 even very low values of σ do not lead to substantial spillover effects. Hence, also changes in the elasticity of substitution are not helpful in solving the *Shimer-puzzle of international trade.*

Up to now we have analyzed our model for the case of $\nu = 0$, which implies that absolute size effects do not influence the level of unemployment. Hence, whenever we would increase the population in all countries, the rate of unemployment would not change. However, new trade theory (see for example, Helpman and Krugman, 1985) and the new economic geography (see

[19] Note that σ is bounded from below by the condition $\frac{\sigma-1}{\sigma-\beta_i} > b_i$ for given b_i and β_i.

[20] This can be seen from rearranging equation (2).

for example, Fujita, Krugman, and Venables, 1999; or Baldwin, Forslid, Martin, Ottaviano, and Robert-Nicoud, 2003) emphasize the role of market size for explaining the pattern of trade as well as the agglomeration of industries and activities. Hence, we next investigate how changes in the degree of external economies of scale, ν, affect the spillover. We therefore vary ν between 0 and 0.99.[21]

We find that stronger external economies of scale result in more pronounced unemployment effects in all countries. The reason is that now the relative-price effect is reinforced because the *absolute size* of the countries matters while this effect is sterilized with $\nu = 0$. A larger market implies higher demand, leading to more production and, therefore, lower unemployment. However, if unemployment benefits rise, the demand shrinks due to lower income (resulting from less efficient institutions). A higher degree of external economies of scale reinforces this process, leading in the end to higher unemployment in the country where the unemployment benefits rise. The spillovers for the trading partner are also larger with a higher degree of external economies of scale due to the shrinking export market. However, as this increase appears in both the country where the labor market reform takes place and the trading partners, it does not affect relative magnitudes. The predicted spillovers are still two orders of magnitude smaller abroad. Hence, the exact value of ν is therefore also not responsible for the *Shimer-puzzle of international trade*.

7 Conclusions

Recent theoretical contributions investigated how institutional labor market reforms affect countries at home and abroad. They found that spillovers due to the changes in relative prices and the selection of firms lead to a positive correlation of changes in unemployment. But are those spillovers *quantitatively* important?

In order to investigate the quantitative theoretical predictions of spillovers, we propose an asymmetric multi-country single-sector trade model with heterogeneous firms, plant-level in-

[21] While $\nu = 0$ sterilizes the absolute size effects, $\nu = 1$ corresponds to the standard Krugman (1980) and Melitz (2003) case.

creasing returns to scale, product differentiation, and search frictions on the labor market. We calibrate the model in order to match stylized facts of the US economy. In the employed model, a worsening of labor market institutions at home unambiguously increases unemployment both at home and in home's trading partners. The relative strength of this positive link is stronger the larger the country where the reforms take place and the smaller the trading partners are. Further, more centrally located countries are able to spillover a larger part of the negative impact to trading partners than more peripheral ones. However, the size of the spillovers, as compared to the effect in the country where the labor market reform occurs, is small. It is about two orders of magnitudes smaller.

This is in contrast to recent empirical findings, suggesting that the spillovers amount to about a tenth. This result is similar to the inability of the search-and-matching model to explain changes in unemployment over the business cycle. We therefore call this finding the *Shimer-puzzle of international trade.*

Motivated by the macro-labor literature on the Shimer-puzzle, we introduce real wage rigidity. As it turns out, with perfectly rigid wages the size of the spillovers increases to one half of the size of the effect in the country where the labor market reform occurs. Hence, while perfect real wage rigidity leads to excessively strong spillovers, search-and-matching labor market frictions with flexibly bargained wages lead to insufficiently small effects. Our investigations therefore suggest that a proper empirical quantification should be based on a framework with search-and-matching labor market frictions combined with a more rigid wage curve than resulting from flexible wage bargaining.

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