

# Globalization and Labor Market Outcomes: Wage Bargaining, Search Frictions, and Firm Heterogeneity\*

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## **Abstract**

Motivated by strong evidence on labor market turnover and firm heterogeneity, we introduce search unemployment à la Pissarides (2000) into Melitz's (2003) trade model. We allow wages to be individually or collectively bargained and analytically solve for the equilibrium. Our results show that the selection effect of trade is unambiguously beneficial to employment. We discuss three liberalization scenarios: (i) a reduction of variable trade costs, (ii) the entry of new trading countries, and (iii) a reduction of fixed market access costs. In scenarios (i) and (ii), the equilibrium rate of unemployment falls because the average productivity increases. In scenario (iii), the relationship between liberalization and employment is ambiguous. We also provide econometric evidence in line with our theoretical predictions.

JEL Classification: F12, F15, F16

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# 1 Introduction

Public opinion often meets globalization with mixed feelings. People tend to agree that consumers benefit from trade but they are at the same time deeply concerned by its impact on job security. Fueled by numerous headlines about layoffs and outsourcings, many fear that globalization will worsen their prospects on the labor market (Scheve and Slaughter, 2001; Caplan, 2006). To a certain extent, economic theory can rationalize this fear. Workers who lose their jobs due to liberalization have to go through a period of active search before finding new employment opportunities. During this period of transition, job reallocations increase the amount of frictions in the labor market which mechanically pushes up the rate of unemployment. On the other hand, comparatively little is known about the long-run effect of trade liberalization on unemployment. This is largely because equilibrium theories of trade and labor are still poorly integrated. We try in this paper to make some progress in that direction by proposing a framework which combines the dominant approaches in each field. More precisely, we integrate the trade model of Melitz (2003) with Pissarides' canonical model of equilibrium unemployment.

We find that, in most cases, liberalizing trade between symmetric countries lowers their equilibrium rates of unemployment. Driving our result is the *selection effect* uncovered by Melitz (2003). By eliminating inefficient firms and making productive firms larger, trade boosts aggregate productivity. Our contribution consists in proving that this cleansing effect is unambiguously beneficial to employment when variable trade costs fall or the number of trading nations goes up. As the cost of vacancy posting relative to the productivity of the average firm decreases, employers intensify their recruitment efforts. This obviously raises the ratio of job vacancies to unemployed workers, which leads to higher employment and higher real wages.

Although our model features firms with heterogeneous productivity, monopoly power on product markets and, due to search frictions, monopsony power on labor markets, we are able to characterize the equilibrium in closed-form. The system of equilibrium conditions turns out to be recursive. We show that the selection of operating and exporting firms does not depend on labor market conditions. Hence, one can follow the same steps than Melitz (2003) to compute the average productivity in the economy. Then, as in the standard Mortensen-Pissarides model, the labor market equilibrium can be derived using solely two equations: a job creation and a wage curve.

The analysis of the wage setting mechanism is the most challenging part of the analysis because search theory typically relies on perfect competition and constant returns to scale.

Introducing monopoly power implies that we have to consider instead multiple-workers firms. We analyze two alternative bargaining environments: *individual wage bargaining*, as micro-founded by Stole and Zwiebel (1996); and *efficient collective bargaining*, where unions and firms negotiate simultaneously about firm-level employment and wages. We establish that, in both cases, wages are identical across firms. This result allows us to aggregate the model in a tractable way. Furthermore, bargaining institutions do not undo the beneficial link between trade openness and unemployment, but they condition it: collective bargaining involves some rent sharing, which gives an equilibrium outcome with higher real wages and higher unemployment relative to the case of individual bargaining.

In the empirical part of the paper, panel data from 20 rich OECD countries allows us to document our theoretical findings. Without formally testing our model, the results presented in this section are consistent with our theory. We use prime-age, youth, and total unemployment rates as dependent variables, and experiment with a host of different openness measures. We run cross-country unemployment regressions and address potential endogeneity concerns using generalized methods of moments. Controlling for the business cycle, macro shocks, and labor market institutions, we find robust evidence that openness is negatively correlated with unemployment across a panoply of specifications. For example, a one-standard-deviation increase in current-price trade openness (total trade over GDP) lowers the prime-age rate of unemployment by between 2 and 3 percentage points. Similarly consistent with our theory, bargaining institutions condition the effect of openness but do not overturn its sign. Hence, both our theoretical and empirical analyses suggest that public concerns about an adverse long-run relation between globalization and unemployment are probably exaggerated.

**Related literature.** This paper builds on our earlier work (Felbermayr and Prat, 2007) where we introduce search unemployment into a closed economy version of Melitz (2003) with the aim to study product market regulation. The relation to the present paper is straightforward, since trade liberalization can be understood as an alternative type of product market reform. In modeling bargaining regimes, we draw on Ebell and Haefke (2006), who analyze a closed-economy, *homogeneous* firms model of search and unemployment.

There is a growing number of theory papers on the trade-unemployment relationship. Our approach is closely related to the recent work of Egger and Kreckemeier (2006), who study the effect of trade liberalization on unemployment in a Melitz trade model with *fair wages*. They find that trade increases the wage dispersion among identical workers and also leads to

more unemployment. Variable trade costs play a key role: if they are zero, unemployment is no different under autarky than under free trade. Davis and Harrigan (2007) find similar results for the degree of wage dispersion and unemployment, using an efficiency wages approach instead of fair wages. Even more closely related to our approach is Janiak’s (2007) model. He also analyzes an open economy with heterogeneous firms and search frictions. His focus differs, however, since he puts the emphasis on short-run adjustments so that its model yields a positive impact of trade on unemployment. Furthermore, he uses a different solution concept where the existence of the equilibrium depends on the elasticity of substitution between varieties.

Mitra and Ranjan (2007) and Helpman and Itskhoki (2007) introduce search unemployment in two-sector models with heterogeneous firms. Their papers differ from ours in terms of motivation and setup: Mitra and Ranjan discuss the role of off-shoring; Helpman and Itskhoki focus on how labor market distortions diffuse internationally through trade. In contrast to our paper, the symmetric version of Helpman and Itskhoki features a negative trade-unemployment link: trade boosts average productivity in the differentiated goods sector, making employment there more attractive. This leads to a reallocation of labor from the distortion-free numeraire sector into the friction-ridden differentiated goods sector.

The remainder of the paper is organized as follows. Section 2 lays-out the set-up of the model. In section 3, we analyze two ways of endogenizing wages: individual bargaining and efficient collective bargaining. In section 4, we describe exit and entry of firms. Section 5 studies the effects of three globalization scenarios: *(i)* a reduction in variable trade costs, *(ii)* an increase in the number of trade relations, *(iii)* a reduction in fixed exporting costs. Section 6 follows established practice in the literature and calibrates the model in order to quantify the magnitude of the effects. Section 7 offers an empirical view on the trade-unemployment nexus. Section 8 concludes. Proofs of the propositions, lemmata and corollaries are included in the Appendix.

## 2 Setup of the Model

We consider an economy that is essentially similar to the one analyzed in Melitz (2003) but for the existence of search frictions in the labor market. We view the world as a collection of symmetric countries which interact on product markets.<sup>1</sup>

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<sup>1</sup>Due to symmetry, we do not use country indices; for brevity, we skip the special case of autarky.

**Final output producers.** The setup of the production side of our model is akin to Egger and Kreickemeier (2006).  $Y$  can be either consumed or used as an input in the production process. Using a continuum of intermediate inputs, a large number of firms produce the final consumption good under conditions of perfect competition. Denoting the quantity of such an input  $q(\omega)$ , we posit the following production function

$$Y = \left[ M^{-\frac{\eta}{\sigma}} \int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \eta \in [0, 1], \quad (1)$$

where the measure of the set  $\Omega$  is the mass  $M$  of available intermediate inputs (produced domestically and imported) and  $\sigma$  denotes the elasticity of substitution between any two varieties of inputs. The normalization by  $M^{-\eta/\sigma}$  allows us to measure the importance of *external economies of scale*. If  $\eta = 0$ , the production function collapses to the standard formulation with a maximum degree of scale economies. If  $\eta = 1$ , we retrieve the functional form used by Blanchard and Giavazzi (2003). The latter choice of parameter avoids a negative correlation between country size and the unemployment rate in the model, which would be largely counterfactual. Nonetheless, we allow for  $\eta \in [0, 1]$  to accommodate the dominant practice in the trade literature, where gains due to increased diversity are generally deemed important. Most of our results do not depend on the precise value of  $\eta$ .

The price index dual to (1) is  $P = [M^{-\eta} \int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega]^{1/(1-\sigma)}$ , where  $p(\omega)$  is the price of input  $\omega$ . We choose the final output good as the *numéraire*, hence  $P = 1$ . Then the demand of intermediate inputs  $\omega$  reads

$$q(\omega) = \frac{Y}{M^\eta} p(\omega)^{-\sigma}. \quad (2)$$

**Intermediate input producers.** At the intermediate inputs level, a continuum of monopolistically competitive firms produce each a unique variety. Thus we may also index firms by  $\omega$ . Labor is the unique factor of production. It is inelastically supplied by the household and enters firms' production functions linearly. Firms have different productivity levels  $\varphi(\omega)$ , so that output  $q(\omega) = l(\omega) \varphi(\omega)$ . Each firm  $\omega$  produces a specific variety  $\varphi$ ; in the following, we use  $\varphi$  to index intermediate input producers.

Input producers have to pay a sunk set-up cost of  $F$  in order to initiate production. Afterward, they may be active on the domestic market and on  $n$  perfectly symmetric foreign markets. Entry into each of these export markets entails a fixed investment cost of  $F_X$ . Sales to foreign clients are affected by variable iceberg transportation costs  $\tau \geq 1$ , so that foreign revenues are lower than domestic ones. We assume that  $\tau^{\sigma-1} F_X > F$ . As explained below, this ensures that

only a subset of firms export and that they are on average more efficient than non-exporting firms.

If it decides to serve both domestic and foreign markets, a firm allocates its output so as to maximize its total revenues. In order to deliver a unit of input to a foreign market, the firm has to manufacture  $\tau$  units. Operating revenues from sales on a given foreign market are therefore equal to  $p_X q_X / \tau$ .<sup>2</sup> By symmetry, demands on the domestic and foreign markets are given by equation (2). Equating marginal revenues across markets therefore yields  $p_X(\varphi) = \tau p_D(\varphi)$  and  $q_X(\varphi) = \tau^{1-\sigma} q_D(\varphi)$ , where  $D$  and  $X$  denote the domestic and the export market. Hence, total revenues are given by

$$R(l; \varphi) \equiv \left[ \frac{Y}{M^\eta} (1 + I(\varphi) n \tau^{1-\sigma}) \right]^{1/\sigma} (\varphi l)^{\frac{\sigma-1}{\sigma}}, \quad (3)$$

with  $I(\varphi)$  being an indicator function that takes value one when a  $\varphi$ -firm exports and zero otherwise. Apart from the fact that their effective demand level is multiplied by  $1 + n\tau^{1-\sigma}$ , exporting firms have similar revenues functions than non-exporting firms.

In order to facilitate the aggregation procedure, we define the average productivity level  $\tilde{\varphi}$  such that  $q_D(\tilde{\varphi}) = Y/M^{\frac{\sigma-\eta}{\sigma-1}}$ . Reinserting this expression into the demand for intermediate inputs (2) yields  $p_D(\tilde{\varphi}) = M^{\frac{1-\eta}{\sigma-1}}$ . In the benchmark case where there are no externalities of scale, so that  $\eta = 1$ , the domestic sale  $q_D(\tilde{\varphi})$  of the average firm is equal to the average sell per firm  $Y/M$ , and the domestic price of its good  $p_D(\tilde{\varphi}) = P = 1$ .

**Search frictions.** The labor market is imperfectly competitive due to the existence of search frictions. Whereas marginal recruitment costs are increasing at the aggregate level because of congestion externalities, they are exogenous from a firm's point of view. The aggregate matching function is linearly homogeneous so that the vacancy-unemployment ratio uniquely determines the rate  $m(\theta)$  at which firms fill their vacancies. That rate is obviously a decreasing function of  $\theta$ . Similarly, due to the homogeneity of degree one of the matching function, job seekers meet firms at the rate  $\theta m(\theta)$  which is increasing in  $\theta$ . The cost of posting vacancies is proportional to the parameter  $c$ , so that recruiting  $l$  workers entails spending  $(c/m(\theta))l$ . In other words, firms face an adjustment cost function that is linear in labor.

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<sup>2</sup>Notice that  $p_X$  is the c.i.f. price in the foreign market.

### 3 Labor Market Equilibrium

This section characterizes the labor market equilibrium for the two most common models of wage determination, individual and collective bargaining. We establish that, in both cases, wages are constant across firms and that the vacancy-unemployment ratio is increasing in the average productivity  $\tilde{\varphi}$ . In the subsequent analysis, we will index endogenous variables by the subscript  $I$  or  $C$  to indicate individual or collective bargaining.

We devise our model in discrete time. All payments are made at the end of each period. Before the beginning of the next period, firms and workers are hit by idiosyncratic shocks: (i) with probability  $\delta$ , intermediate producers are forced to leave the market; (ii) with probability  $\chi$ , each job is destroyed because of match-specific shocks. We assume that these two shocks are independent so that the actual rate of job separation is  $s = \delta + \chi - \delta\chi$ .

#### 3.1 Individual wage bargaining

Individual wage bargaining involves the following sequence of actions: at each period, the intermediate input producer decides about the optimal quantity of vacancies  $v_I$ , taking the wage rate as given. The matching technology brings together the workers and the firm. Before production takes place, wages are bargained. Wage contracts are unenforceable: at any point in time, the firm may fire any employee and symmetrically any employee may decide to quit. Solving the game by backward induction, we first characterize the firm's optimal vacancy setting behavior, and then solve the bargaining problem.

The market value of an intermediate producer solves

$$J_I(l_I; \varphi) = \max_{v_I} \frac{1}{1+r} \{ R(l_I; \varphi) - w_I(l_I; \varphi)l - cv_I - f - I(\varphi)nf_X + (1-\delta)J_I(l'_I; \varphi) \}, \quad (4)$$

$$s.t. \ (i) \ R(l_I; \varphi) = \left[ \frac{Y}{M^\eta} (1 + I(\varphi)n\tau^{1-\sigma}) \right]^{1/\sigma} (\varphi l_I)^{\frac{\sigma-1}{\sigma}},$$

$$(ii) \ l'_I = (1-\chi)l_I + m(\theta_I)v_I,$$

where  $l'_I$  is the level of employment next period, and the dependence of  $l_I, v_I$  and  $q_I$  on  $\varphi$  is understood. Constraint (i) is the revenue function (3) and (ii) gives the law of motion of employment at the firm level. The first order condition for vacancy posting reads

$$\frac{c}{m(\theta_I)} = (1-\delta) \frac{\partial J_I(l'_I, \varphi)}{\partial l'_I}, \quad (5)$$

so that the firm sets the shadow value of labor equal to the marginal recruitment cost. Substituting the constraints into the objective function of the firm, differentiating with respect to  $l_I$ , and using the optimality condition (5) yields

$$\frac{\partial J_I(l_I, \varphi)}{\partial l_I} = \frac{1}{1+r} \left[ \frac{\partial R(l_I; \varphi)}{\partial l_I} - w_I(l_I, \varphi) - \frac{\partial w_I(l_I, \varphi)}{\partial l_I} l_I + \frac{c}{m(\theta_I)}(1-\chi) \right]. \quad (6)$$

The Firm acts as a monopsonist by taking into account the effect of additional employment on the wage of inframarginal employees.

Replacing the first order condition (5) on the left-hand side of (6), we obtain

$$\frac{\partial R(l_I; \varphi)}{\partial l_I} = w_I(l_I, \varphi) + \frac{\partial w_I(l_I, \varphi)}{\partial l_I} l_I + \frac{c}{m(\theta_I)} \left( \frac{r+s}{1-\delta} \right). \quad (7)$$

This expression differs from Melitz (2003) in that marginal costs are augmented by the monopsonistic effect and recruitment costs.

The outcome of the bargaining process satisfies the following “surplus-splitting” rule

$$(1-\beta) [E_I(l; \varphi) - U_I] = \beta \frac{\partial J_I(l; \varphi)}{\partial l_I}, \quad (8)$$

where  $E_I(l; \varphi)$  denotes the asset value of a worker employed at a firm with productivity  $\varphi$  and size  $l$ , while  $U_I$  is the value of being unemployed. Individual bargaining implies that each employee is treated as the *marginal* worker. This is why condition (8) requires that the value of the job for the firm is equal to the shadow value of labor. Obviously, the parameter  $\beta$  measures the bargaining power of the worker and thus belongs to  $[0, 1]$ .

As explained by Stole and Zwiebel (1996a), condition (8) can be micro-founded either by cooperative or non-cooperative game theory. In the non-cooperative case, condition (8) characterizes the unique subgame perfect equilibrium of an extensive form game where the firm and its employees play the alternating-offer bargaining game of Binmore et al. (1986) *within* each bargaining session. Accordingly, neither the firm nor any employee can improve their positions by renegotiating. In the cooperative case, condition (8) assigns to each party its Shapley value, that is the average, over all possible permutations, of each player contribution to possible coalitions ordered below him.<sup>3</sup> When  $\beta$  differs from 1/2, condition (8) generalizes the symmetric Shapley value to situations where players are not treated identically.

Using the shadow value of labor (6) in the bargaining solution (8), we obtain a differential equation in the wage rate, which can be solved to give rise to a *Wage curve* ( $W_I$ ). The equilibrium wage and labor market tightness are found by interacting  $W_I$  with a *Job Creation curve*

<sup>3</sup>This interpretation is the one favored by Helpman and Itskhoki (2007).



( $JCI$ ), as in standard search-matching models. The following proposition characterizes the labor market equilibrium under individual bargaining. Proofs are relegated to the Appendix.

**Proposition 1** *The labor market admits an equilibrium if and only if  $b < M_I^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}_I \left( \frac{\sigma-1}{\sigma-\beta} \right)$ , where  $b$  is the flow value of non-market activity. The equilibrium is unique and such that wages are constant across firms. The equilibrium wage,  $w_I$ , and vacancy-unemployment ratio,  $\theta_I$ , simultaneously satisfy the following Wage and Job Creation conditions:*

$$W_I: \quad w_I(\varphi) = b + \frac{\beta}{1-\beta} \left( \frac{c}{m(\theta_I)} \left( \frac{r+s}{1-\delta} \right) \right) + \frac{\beta}{1-\beta} \frac{c\theta_I}{1-\delta} \quad (9)$$

$$JCI: \quad w_I(\varphi) = M_I^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}_I \left( \frac{\sigma-1}{\sigma-\beta} \right) - \frac{c}{m(\theta_I)} \left( \frac{r+s}{1-\delta} \right) \quad (10)$$

The Job Creation curve characterizes firms' optimal recruitment policies. As expected, the number of posted vacancies (and, hence, also  $\theta$ ) are decreasing in the wage level. According to the Wage curve, workers are paid similarly across firms. This somewhat surprising result extends the proof of Stole and Zwiebel (1996a) that firms exploit their monopsony power until employees are paid their outside option to a dynamic setting. In our case, the outside option is augmented by the recruitment costs,  $c/m(\theta_I)$ , that the firm would have to pay if it were to replace the worker. Quite intuitively, the workers' bargaining position improves in the severity of labor market frictions which explains why the Wage curve is increasing in  $\theta$ .

Note that the existence condition stated in Proposition 1 states that the flow value of non-market activity,  $b$ , should not yield revenues in excess of a share  $(\sigma-1)/(\sigma-\beta) < 1$  of average market revenues  $M_I^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}_I = \tilde{\varphi}_I p(\tilde{\varphi}_I)$ .

Figure 1 illustrates the effect of an increase in average productivity  $\tilde{\varphi}_I$  on labor market outcomes. The Job Creation curve shifts upwards because firms are on average more productive and search more intensively for workers. On the other hand, the Wage curve is independent of  $\tilde{\varphi}_I$  because there is no rent-sharing. As explained before, wages solely depend on the workers' outside option. Hence, the relationship between  $\tilde{\varphi}_I$  and  $\theta$  is unambiguously positive.

### 3.2 Collective bargaining

In a firm covered by collective bargaining, workers form a firm-wide coalition, that is, a trade union. When bargaining fails and workers go on strike, the firm loses not only the value associated to the marginal worker, as with individual bargaining, but its entire labor force. We opt

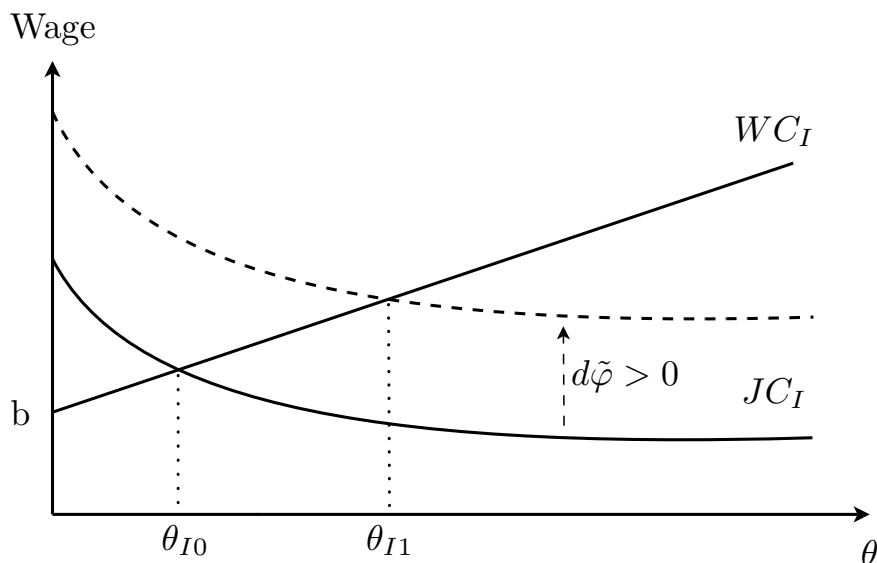


Figure 1: Effect of  $\tilde{\varphi}_I$  in the Individual Bargaining regime.

for an *efficient bargaining* setup so that the firm and the union bargain about both wages and employment. This ensures that we are considering equilibria lying on the Pareto frontier.<sup>4</sup>

Negotiations between the union and the firm take place in the first period.<sup>5</sup> The union's objective is the expected sum of its members' rents

$$\mathbf{U}(l, w) \equiv (1 - \delta)l \left[ \frac{w - rU}{r + \delta} \right],$$

while the firm seeks to maximize its expected variable profits

$$\mathbf{F}(l, w; \varphi) \equiv \left( \frac{1 - \delta}{r + \delta} \right) \left[ R(l; \varphi) - wl(\varphi) - \frac{c}{m(\theta)} \chi l(\varphi) \right] - \frac{c}{m(\theta_C)} l.$$

The negotiation specifies both employment and wages. The solution lies on the contract curve which connects the points where the firm iso-profit curves are tangent to the union indifference

<sup>4</sup>Our main results, however, also hold in a *right to manage* set-up where unions negotiate only about wages and firms have full freedom to set the level of employment. Barth and Zweimüller (1995) study different wage bargaining scenarios when firms are heterogeneous with respect to their productivity.

<sup>5</sup>One could instead consider that the firm and the union bargain on the steady-state profits, so that  $\mathbf{F}(l, w; \varphi) = \left( \frac{1 - \delta}{r + \delta} \right) \left[ R(l; \varphi) - wl(\varphi) - \frac{c}{m(\theta)} \chi l(\varphi) \right]$ . This obviously generates a hold-up problem where the union does not take into account the initial recruitment costs. Then employment is lower and wages higher but the main insights of this section are not fundamentally modified.

curves. The actual agreement is pinned down by the union's bargaining power  $\beta$ . Proposition 2 shows that the labor market equilibrium can be characterized in a similar fashion than in the Individual Bargaining regime.

**Proposition 2** *The labor market admits an equilibrium if and only if  $b < M^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi} (\sigma - 1) / \sigma$ . The equilibrium is unique and such that wages are constant across firms. The equilibrium wage,  $w_C$ , and vacancy-unemployment ratio,  $\theta_C$ , simultaneously satisfy the following Wage and Job Creation conditions:*

$$W_C: \quad w_C = b + \beta \left( \frac{M^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}_C}{\sigma} \right) \left( \frac{\theta_C m(\theta_C) + r + s}{r + s} \right) \quad (11)$$

$$J_C: \quad w_C = \left( 1 - \frac{1-\beta}{\sigma} \right) M^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}_C - \left( \frac{r+s}{1-\delta} \right) \frac{c}{m(\theta_C)} \quad (12)$$

For the same reasons than before, the Wage curve is increasing in  $\theta$  while the Job Creation curve is decreasing. The bargained wage is equal to the opportunity cost of employment  $rU_C$  plus a share  $\beta$  of the remaining profits per worker. Due to the existence of rent-sharing, and in contrast to individual bargaining, the Wage curve depends on average productivity  $\tilde{\varphi}_C$ . Interestingly, as with individual bargaining, the wage rate is the same across firms with different levels of productivity. Figure 2 illustrates why, in our CES setting, firm-level productivity differences wash out in equilibrium so that there is no wage dispersion.

First consider the curves without dot. The plain curve plots the average revenues per worker while the dashed curve plots the marginal revenues. The competitive outcome where  $\beta = 0$  is obviously given by the point where the marginal revenues function intersects the worker outside option  $rU_C$ . Starting from this point, the contract curve describes a vertical<sup>6</sup> segment that reaches the average revenues function. This upper bound gives the outcome when workers have all the bargaining power ( $\beta = 1$ ) since then firm's profits net of fixed costs are zero. When  $\beta$  varies between 0 and 1, wages fluctuate between these two extremes. Now consider the problem of a firm with a higher productivity  $\varphi_1 > \varphi_0$ . As shown by the dotted curves, the only difference is that both average and marginal revenues functions are shifted to the right. Furthermore, since marginal revenues are equal to average revenues time  $(\sigma - 1)/\sigma$ , the two curves are shifted parallelly. Accordingly, firms with a higher productivity hire more workers but pay the same wage.

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<sup>6</sup>As usual, the verticality of the contract curve follows from the risk neutrality of workers. Introducing risk aversion yields a contract curve with a positive but bounded slope.

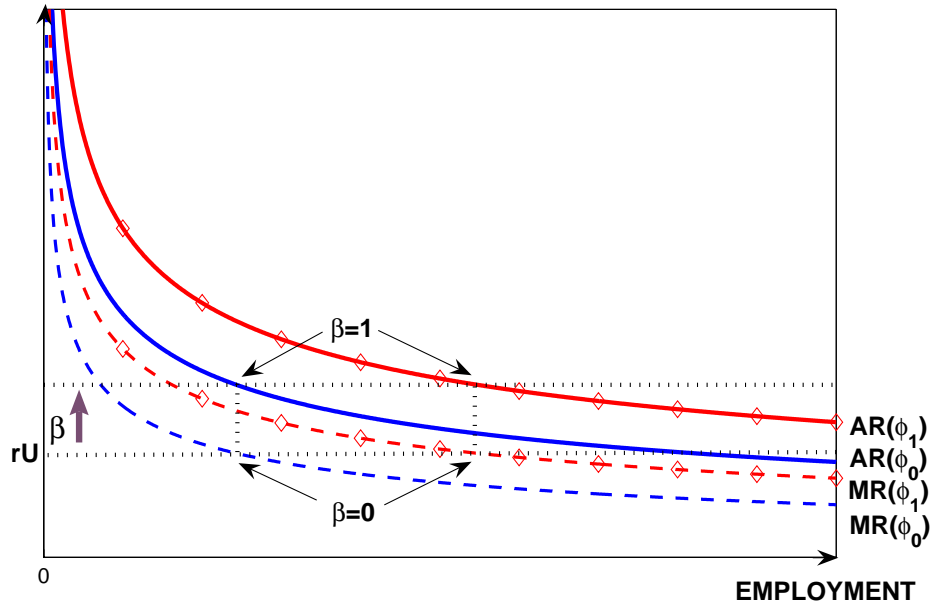


Figure 2: Collective bargaining with  $\varphi_0 < \varphi_1$

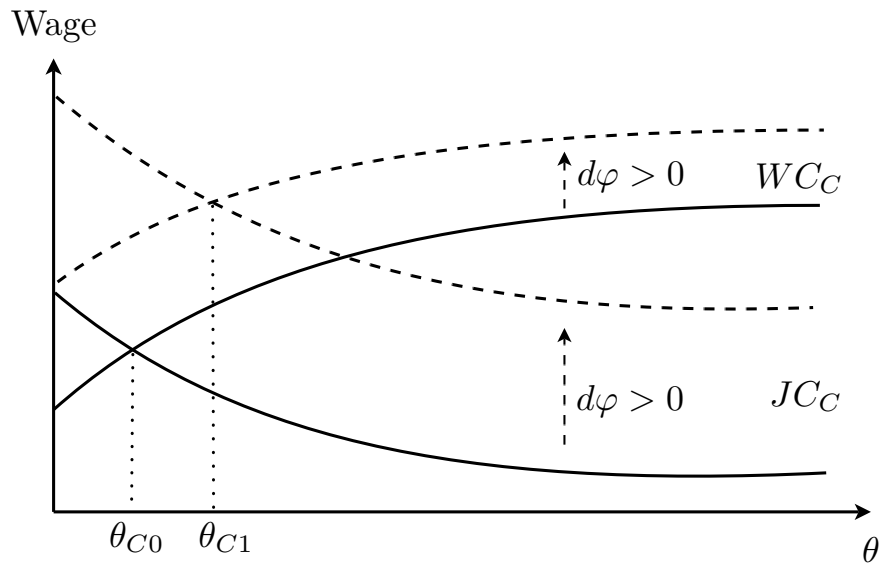


Figure 3: Effect of  $\tilde{\varphi}_I$  in the Collective Bargaining regime.

The most significant difference with the individual bargaining regime is that now average productivity  $\tilde{\varphi}$  shifts up the Wage curve. Thus it is not anymore obvious that  $\tilde{\varphi}$  raises  $\theta$ . It can be shown, however, that the effect on the Wage curve is unambiguously dominated by the shift of the Job Creation curve. Corollary 1 states this result while the equilibrium adjustments are displayed in Figure 3.

**Corollary 1** *The vacancy-unemployment ratio  $\theta$  is increasing in the average productivity of firms  $\tilde{\varphi}$ .*

We have described in this section how to solve for the labor market equilibrium. Our two equilibrium conditions take the average productivity,  $\tilde{\varphi}$ , and the aggregate mass,  $M$ , of intermediate input producers as given. We endogenize these two variables in the following section by explaining how firms are created and destroyed.

## 4 Firm entry and exit

We model firm entry and exit in a similar fashion than Melitz (2003). Thus we deliberately keep the analysis as brief as possible and refer the reader to Melitz's paper for further details. Our contribution is to show that the equilibrium level of productivity  $\tilde{\varphi}$  and the labor market tightness  $\theta$  are independent.

The entry process is in two stages. First, prospective entrants pay an entry cost  $f_E$ . Only after entering do they draw their productivity from a sampling distribution with c.d.f.  $G(\varphi)$  and p.d.f.  $g(\varphi)$ . Given that firms' revenues are obviously increasing in  $\varphi$ , one can define a threshold  $\varphi_D^*$  below which firms do not take up production. Similarly, firms with a productivity between  $\varphi_D^*$  and  $\varphi_X^*$  will serve only their domestic market. The share of exporting firms is therefore equal to  $\varrho \equiv [1 - G(\varphi_X^*)] / [1 - G(\varphi_D^*)]$ . The average level of productivity of intermediate input producers is given by the following weighted sum

$$\tilde{\varphi} = \left\{ \frac{1}{1 + n\varrho} \left[ \tilde{\varphi}_D^{\sigma-1} + \varrho \left( \frac{\tilde{\varphi}_X}{\tau} \right)^{\sigma-1} \right] \right\}^{\frac{1}{\sigma-1}}, \quad (13)$$

where  $\tilde{\varphi}_D$  and  $\tilde{\varphi}_X$  are average productivity indices for the populations of firms that sell only domestically and that also sell abroad, respectively:

$$\tilde{\varphi}(\varphi_D^*) = \left[ \frac{\int_{\varphi_D^*}^{+\infty} \varphi^{\sigma-1} g(\varphi) d\varphi}{1 - G(\varphi_D^*)} \right]^{\frac{1}{\sigma-1}} \quad \text{and} \quad \tilde{\varphi}(\varphi_X^*) = \left[ \frac{\int_{\varphi_X^*}^{+\infty} \varphi^{\sigma-1} g(\varphi) d\varphi}{1 - G(\varphi_X^*)} \right]^{\frac{1}{\sigma-1}}. \quad (14)$$

Let us first characterize the entry threshold  $\varphi_D^*$ . We follow Melitz (2003) and consider that firms amortize their investment costs: at the end of each period, they pay  $f = F(r + \delta)$  and  $f_X = F_X(r + \delta)$  per export market. Notice that, since all uncertainty is resolved after the productivity draw, the two approaches deliver identical predictions. The linearity of the adjustment cost function implies that firms reach their optimal size by the end of their first period of activity.<sup>7</sup> It is profitable to start operating and to recruit workers when

$$(1 - \delta) \sum_{t=0}^{\infty} (1 - r - \delta)^t \pi_D(\varphi) - \frac{c}{m(\theta)} l_D(\varphi) - f = (1 - \delta) \frac{\pi_D(\varphi)}{r + \delta} - \frac{c}{m(\theta)} l_D(\varphi) - f \geq 0, \quad (15)$$

where  $\pi_D(\varphi)$  is the optimal flow profit from domestic sales of a  $\varphi$ -firm

$$\pi_D(\varphi) = p_D(\varphi)\varphi l_D(\varphi) - w l_D(\varphi) - \frac{c}{m(\theta)} \chi l_D(\varphi) - f.$$

The entry condition (15) takes into account the fact that firms pay the setup and vacancy costs upfront but have to wait one period to recruit their workers. In this period, they can also be hit by a destruction shock so that, with probability  $\delta$ , they never start to produce. The cut-off productivity  $\varphi_D^*$  is such that the weak inequality in (15) binds. The proportionality of domestic prices allows us to relate operating profits of the marginal and average firm

$$\frac{\pi_D(\tilde{\varphi}_D) + f}{\pi_D(\varphi_D^*) + f} = \frac{l_D(\tilde{\varphi}_D)}{l_D(\varphi_D^*)} = \left( \frac{\tilde{\varphi}_D}{\varphi_D^*} \right)^{\sigma-1}.$$

Hence, (15) is equivalent to the following *Zero Cutoff Profit* condition

$$\pi_D(\tilde{\varphi}_D) = \left( \frac{r + \delta}{1 - \delta} \right) \left[ \frac{c}{m(\theta)} l_D(\tilde{\varphi}_D) \right] + f \left[ \left( \frac{\tilde{\varphi}_D}{\varphi_D^*} \right)^{\sigma-1} \left( \frac{1 + r}{1 - \delta} \right) - 1 \right]. \quad (16)$$

The choice of exporting status can be characterized in a similar fashion. One simply has to replace the subscripts  $D$  in equation (15) by  $X$  and to update the definition of profits as follows

$$\pi_X(\varphi) = p_X(\varphi)\varphi l_X(\varphi)/\tau - w l_X(\varphi) - \frac{c}{m(\theta)} \chi l_X(\varphi) - f_X.$$

Given that export prices are also proportional to productivity, we obtain a similar *Zero Cutoff Profit* condition for exporting firms

$$\pi_X(\tilde{\varphi}_X) = \left( \frac{r + \delta}{1 - \delta} \right) \left[ \frac{c}{m(\theta)} l_X(\tilde{\varphi}_X) \right] + f_X \left[ \left( \frac{\tilde{\varphi}_X}{\varphi_X^*} \right)^{\sigma-1} \left( \frac{1 + r}{1 - \delta} \right) - 1 \right]. \quad (17)$$

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<sup>7</sup>Gradual convergence can be restored either by considering that recruitment costs are convex in the number of posted vacancies, as in Bertola and Caballero (1994), or by assuming that firms can post only one vacancy, as in Acemoglu and Hawkins (2007). Since this greatly complicates the aggregation procedure, we adopt a more parsimonious specification where, as in Melitz (2003), firms jump to their optimal size. See Koeniger and Prat (2007) for a numerical analysis of a model with firm entry and convex adjustment costs.

To see that some firms serve solely their domestic market, notice that  $R_X(\varphi) = p_X(\varphi)q_X(\varphi)/\tau = \tau^{1-\sigma}R_D(\varphi)$  and  $l_X(\varphi) = \tau^{1-\sigma}l_D(\varphi)$ . Accordingly, the flow profits satisfy  $\pi_X(\varphi) = \tau^{1-\sigma}[\pi_D(\varphi) + f] - f_X$ . Replacing this expression in (15) illustrates that, when  $\tau^{\sigma-1}f_x > f$ , a  $\varphi_D^*$ -firm does not find it profitable to incur the exporting cost.<sup>8</sup>

The Zero Cutoff Profit conditions characterize the optimal decision of a firm who know its idiosyncratic productivity. *Free Entry* allows us to take into account the behavior of prospective entrants. Entry occurs until expected profits are equal to the entry cost  $f_E$ , so that

$$\frac{f_E}{1 - G(\varphi_D^*)} = \frac{\pi_D(\tilde{\varphi}_D)}{r + \delta}(1 - \delta) - \frac{c}{m(\theta)}l_D(\tilde{\varphi}_D) - f + n\varrho \left[ \frac{\pi_X(\tilde{\varphi}_X)}{r + \delta}(1 - \delta) - \frac{c}{m(\theta)}l_X(\tilde{\varphi}_X) - f_X \right]. \quad (18)$$

Free entry holds when this equality is satisfied because an entrant will start to operate with probability  $1 - G(\varphi_D^*)$ . On the domestic market, successful entrants earn an average expected stream of profits equal to equation (15), as evaluated for the representative firm  $\tilde{\varphi}_D$ . Moreover, entrants will also export with probability  $1 - G(\varphi_X^*) = \varrho[1 - G(\varphi_D^*)]$  and earn the average expected stream of profits on the export markets. Taking into account these two eventualities leads to equation (18). Combining the Free Entry and Zero Profit Conditions yields

$$f_E = [1 - G(\varphi_D^*)] \left( \frac{1+r}{r+\delta} \right) \left\{ f \left[ \left( \frac{\tilde{\varphi}(\varphi_D^*)}{\varphi_D^*} \right)^{\sigma-1} - 1 \right] + n\varrho f_X \left[ \left( \frac{\tilde{\varphi}(\varphi_X^*)}{\varphi_X^*} \right)^{\sigma-1} - 1 \right] \right\}, \quad (19)$$

Although (19) depends on both  $\varphi_D^*$  and  $\varphi_X^*$ , it actually pins down the two variables because  $\varphi_D^* = \varphi_X^* \tau (f_X/f)^{\frac{1}{\sigma-1}}$ .<sup>9</sup> Given that our equilibrium condition is the same than in Melitz (2003), the existence and uniqueness of the equilibrium in the product market are ensured. Most interestingly, it turns out that  $\theta$  drops out when the Free Entry and Zero Profit Conditions are interacted. This implies that, as stated in the following lemma, the entry and export thresholds solely depend on the product market parameters:  $\{f_E, f, f_X, n, \tau, \sigma\}$ .

**Lemma 1** *The equilibrium average productivity of intermediate producers,  $\tilde{\varphi}$ , does not depend on the vacancy-unemployment ratio  $\theta$ .*

The optimal partitioning of firms is not affected by labor market conditions. Higher search frictions have perfectly countervailing ex-ante and ex-post effects. They reduce entry, so that

<sup>8</sup>When this partitioning does not hold, one cannot use equation (15) to determine whether or not a firm operates on the domestic market because it may be optimal to pay the fixed operating cost  $f$  in order to access the export market.

<sup>9</sup>See the proof of Lemma 1 for a derivation of this equality.

successful entrants face larger residual demands, which improves the odds of selling on the domestic and foreign markets. On the other hand, operating costs are higher ex-post, which makes it harder for inefficient firms to survive. With the CES specification used in the present model, the two effects cancel exactly: the average level of productivity of intermediate goods producers is not affected by labor market frictions. However, higher frictions have to be compensated by larger operating profits. They deter entry and so, as shown in the following section, reduce the equilibrium mass of firms.

## 5 Trade Liberalization and Unemployment

This section discusses three globalization scenarios: *(i)* a reduction of variable trade costs, *(ii)* an increase in the number of trade relations and *(iii)* a drop in the fixed foreign distribution costs  $f_X$ . The first and the third scenario capture technological (transportation costs) and political (tariffs) change, while the second addresses the emergence of new countries into the global trading system. We describe the interaction of trade liberalization and unemployment in two steps. First, we consider the case where trade affects aggregate outcomes through the selection effect only ( $\eta = 1$ ). This isolates the novel mechanism introduced by Melitz (2003). Then we analyze the more intricate case where trade also affects outcomes through an external scale effect, as in Krugman (1979) and in much of the subsequent literature.

### 5.1 The equilibrium rate of unemployment

The equilibrium rate of unemployment is linked to the degree of labor market tightness  $\theta$  and the importance of labor market churning, as captured by  $s$ , via the standard Beveridge curve

$$u(\theta) = \frac{s}{s + \theta m(\theta)}. \quad (20)$$

This condition ensures that the flows in and out of the unemployment pool offset each other. As in standard search-matching models, the rate of unemployment is a decreasing function of the vacancy-unemployment ratio. Since we have shown in Propositions 1 and 2 that  $\theta$  is increasing in the level of aggregate productivity, it is sufficient to know how trade affects  $M^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}$  in order to characterize its impact on employment.

We already know from Melitz (2003) that the selection effect of trade raises  $\tilde{\varphi}$ . Hence, it only remains to determine its influence on  $M$ . As usual, the equilibrium mass of firms is such



that the labor market clears. Given that all workers are employed by domestic firms

$$M_D [l_D(\tilde{\varphi}_D) + n\varrho l_X(\tilde{\varphi}_X)] = [1 - u(\theta)] L, \quad (21)$$

where  $L$  is the size of the labor force. Due to imports from foreign firms, the available number of varieties  $M$  is higher and equal to  $M = M_D (1 + n\varrho)$ .

**Proposition 3** *In the Individual bargaining regime, the equilibrium number of domestically available varieties is given by*

$$\left( (1 + n\varrho)L \left( \frac{\theta_I m(\theta_I)}{s + \theta_I m(\theta_I)} \right) \left( \frac{1 - \beta}{\sigma - \beta} \right) \left( \frac{1 - \delta}{r + s} \right) \tilde{\varphi} \left( \left( \frac{r + \delta}{1 + r} \right) \frac{f_E}{1 - G(\varphi_D^*)} + f + n\varrho f_X \right)^{-1} \right)^{\frac{1 - \sigma}{2 - \sigma - \eta}}. \quad (22)$$

*In the Collective bargaining regime, the equilibrium number of varieties is given by*

$$\left( (1 + n\varrho)L \left( \frac{\theta_C m(\theta_C)}{s + \theta_C m(\theta_C)} \right) \left( \frac{1 - \beta}{\sigma} \right) \left( \frac{1 - \delta}{r + s} \right) \tilde{\varphi} \left[ \left( \left( \frac{r + \delta}{1 + r} \right) \frac{f_E}{1 - G(\varphi_D^*)} + f + n\varrho f_X \right)^{-1} \right] \right)^{\frac{1 - \sigma}{2 - \sigma - \eta}}. \quad (23)$$

The effect of trade on the number of available varieties is *a priori* ambiguous. Although  $M$  is increasing in  $\tilde{\varphi}$  and  $\theta$ , it is decreasing in the cutoff productivity for domestic firms  $\varphi_D^*$  and in the additional exporting costs  $n\varrho f_x$ . Section 6 proposes a calibration of the model which clarifies this ambiguity.

## 5.2 The selection effect of trade liberalization on unemployment

Trade affects the distribution of productivities across intermediate input producers by reallocating labor towards exporters and away from purely domestic firms, both at the extensive and at the intensive margin. In the absence of external economies of scale, i.e. when  $\eta = 1$ , our model's solution is recursive. The mass of varieties available to final goods producers is immaterial for their level of productivity. It drops out from the description of the labor market equilibrium, both in the case of individual and collective bargaining. We can then make use of Lemma 1, which states that the average productivity over intermediate input producers,  $\tilde{\varphi}$ , does not depend on labor market outcomes. To understand the effect of trade liberalization on real wages and unemployment, it is therefore sufficient to see how  $\tilde{\varphi}$  changes in our globalization scenarios.

**Proposition 4** *In the absence of economies of scale, i.e., if  $\eta = 1$ , a reduction of variable trade costs  $\tau$  or an increase in the number of trading partners  $n$  lead to a fall in the equilibrium rate of unemployment and a rise in the real wage, regardless of whether wages are bargained individually or collectively. In the former case, the unemployment reduction is stronger and the real wage effect weaker than in the latter case. A fall in fixed foreign distribution costs has an ambiguous effect on labor market outcomes.*

The novel result in Melitz (2003) is that trade liberalization affects the equilibrium productivity distribution of intermediate input producers. In particular, offering additional opportunities to sell to firms above the productivity threshold  $\varphi_X^*$ , lower variable trade costs  $\tau$  or a higher number of trading countries, unambiguously shifts economic mass towards the most efficient firms. The reallocation of labor requires a higher real wage, which makes it harder for inefficient firms to survive: the least productive producers find it no longer optimal to operate. The cut-off productivity  $\varphi_D^*$  shifts up while  $\tilde{\varphi}_X^*$  falls. The average productivity of exporters falls while that of purely domestic firms rises. Regardless of  $G(\varphi)$ , the average productivity  $\tilde{\varphi}$  of input producers increases. Hence, trade liberalization leads to a “Darwinian” selection of efficient firms.

The ambiguity associated to a reduction in  $f_X$  stems from the fact that the average productivity of exporters now falls strongly. In the extreme, when  $f_X$  goes to zero, all active firms export, which would completely offset the selection effect of trade liberalization.

We have shown in section 3 that higher  $\tilde{\varphi}$  translates into a higher degree of labor market tightness, and, hence, lower rate of unemployment, regardless of the wage bargaining regime. Some of the productivity gain goes into real wages, which have to rise.

### 5.3 The effect of trade with external economies of scale

TO BE COMPLETED

## 6 Calibration and Simulation

Although the model can be solved analytically, some ambiguities arise concerning the aggregate average productivity. Thus, we further illustrate our theoretical findings by performing comparative static exercises on a calibrated version of the model. In all these scenarios, we focus on

the long-run and neglect the complex dynamic adjustment process in the two state variables of the model,  $\theta$  and  $\tilde{\varphi}_t$ .<sup>10</sup> Additionally, we calibrate the model for the U.S. economy and the European economy separately. We assume that collective bargaining is dominant in the European economy, whereas individual bargaining is dominant in the U.S. economy.

## 6.1 Calibrating the free trade equilibrium

As it is quite common in models dealing with firm heterogeneity, calibration is done by using a Pareto distribution with probability density

$$g(\varphi) = \gamma \frac{1}{\varphi} \left( \frac{\bar{\varphi}}{\varphi} \right)^\gamma, \quad (24)$$

where  $\gamma$  denotes the appendant dispersion index and  $\bar{\varphi}$  denotes the lower bound of the Pareto distribution. Inserting the complementary cumulative distribution function into equation (13) yields a unique solution for the average productivity under autarky

$$\tilde{\varphi} = \left( \frac{\gamma}{\gamma + 1 - \sigma} \right)^{\frac{1}{\sigma-1}} \varphi^*. \quad (25)$$

One of the main properties of the Melitz model is that the average productivity increases in  $\varphi^*$ . Hence, the term in brackets must be greater than unity, which is the case if  $\gamma > \gamma + 1 - \sigma$ . We use a Cobb-Douglas matching function, so that:  $m(\theta) = m_0 \theta^{-\alpha}$ , where  $\alpha$  is the elasticity of the matching function and  $m_0$  is its scale parameter.

**Parameters for calibration of the U.S. economy.** In order to parameterize the matching function for the U.S. economy, the job finding and vacancy filling rates are set according to Shimer (2005) and Hall (2005). Shimer (2005) estimates the monthly job finding rate in the U.S. to be around 0.45, whereas Hall (2005) estimates an average ratio of vacancies to unemployed workers of 0.539. Given that the matching function has constant returns to scale, the vacancy-unemployment ratio  $\theta$  is also equal to the job finding-job filling rates ratio. The monthly job filling rate is pinned down by the job finding rate and the equilibrium tightness, which yields a job filling rate close to 0.9.

Our time period is normalized to one year. Each period, a fraction of  $\delta = 0.11$  firms exit the market due to an exogenous shock. According to Shimer (2005), the monthly rate of job separation equals 0.034, which yields an annual rate equal to 0.408. Notice that the rate of job

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<sup>10</sup>For this reason, we also refrain from welfare considerations.

separation includes the rate of firms' death, which must be subtracted in order to derive the arrival rate of match-specific shocks  $\chi = 0.298$ .

Table 1: *Calibration-Parameter Values*

<i>Parameter</i>	<i>Interpretation</i>	<i>Value</i>	<i>Source</i>
$r$	Discount rate	0.040	90's average interest rate
$b_{US}$	Value of non-market activity in the U.S.	0.28	30% replacement rate
$b_{EU}$	Value of non-market activity in Europe	0.5	Ebell and Haefke (2003)
$\alpha_{US}$	Elasticity of Matching function for the U.S.	0.500	Petrongolo and Pissarides (2001)
$\alpha_{EU}$	Elasticity of Matching function for Europe	0.400	Petrongolo and Pissarides (2001)
$m_{0US}$	Scale of Matching function in the U.S.	7.630	Job finding rate=5.4
$m_{0EU}$	Scale of Matching function in Europe	4.7024	Job finding rate=3
$\beta_{US}$	Bargaining power in the U.S.	0.500	Abowd and Allain (1996)
$\beta_{EU}$	Bargaining power in Europe	0.200	Cahuc et al. (2002)
$\delta$	Rate of firm exit	0.110	Firm turnover rate=22%
$\chi_{U.S.}$	Rate of match-specific separation	0.298	Hogan and Ragan (1995)
$\chi_{EU}$	Rate of match-specific separation	0.058	Hogan and Ragan (1995)
$\sigma$	Elasticity of substitution	3.8	Bernard et al. (2007)
$\gamma_{US}$	Decay of Prod. distribution	3.4	Bernard et al. (2007)
$\gamma_{EU}$	Decay of Prod. distribution	3.5	$\theta = 0.1$
$c_{US}$	Cost of posting a vacancy in the U.S.	1.350	Recruitment costs=1.5 · Job fill.
$c_{EU}$	Cost of posting a vacancy in Europe	1.54	Recruitment costs=1.5 · Job fill.
$f_E$	Entry costs	3.4826	$\theta = 0.5$
$f$	Flow fixed costs	0.1155	Average firm size = 19

Note: All parameter values and statistics are for yearly time periods.

Following the paper of Petrongolo and Pissarides (2001), the elasticity of the matching function  $\alpha$  was set equal to 0.5. Additionally, the bargaining power is set equal to the elasticity of the matching function, which is in line with the estimates of Abowd and Allain (1996). Finally, the interest rate is set equal to 4% so as to match the U.S. average interest rate in the 1990's.

**Parameters for the calibration of the European economy.** We had to adjust the values for the following parameters in order to calibrate the European economy. Following the example of Blanchard and Gali (2006), the monthly job finding rate for the European economy is set lower than for the U.S. economy. They estimate the job finding rate for the U.S. equal to 0.3

and set the job finding rate for Europe equal to 0.1. We follow their example and set the job finding rate for the European economy equal to 0.1.<sup>11</sup> For the European economy we target a lower equilibrium market tightness than in the U.S. economy equal to 0.1 due to the findings of Hogan and Ragan (1995).<sup>12</sup> This leads to a monthly job filling rate equal to 1.0267 and the value 4.7024 for the scale parameter  $m_0$  of the matching function. The elasticity of the matching function is again set according to the findings of Petrongolo and Pissarides (2001) and the bargaining power of the workers is set according to the paper of Cahuc et al. (2001). Cahuc et al. estimated the elasticity of the matching function to equal 0.2. Their estimations are based on data from France. Notice that the collective bargaining mechanism is dominant in France as far as wage bargaining is concerned. The dispersion index of the Pareto distribution is adjusted to 3.5, which, in combination with the parameters discussed above, yields a situation where unemployment converges to 12% and  $\theta$  converges to 0.1 for infinite variable transport cost.<sup>13</sup>

**Distribution function** The dispersion index of the Pareto distribution is set equal to 3.4 and the elasticity of substitution is equal to 3.8, both values were set according to Bernard et al. (2007). The expected value of  $\varphi$  is given by

$$E[\varphi] = \left( \frac{\gamma}{\gamma - 1} \right) \bar{\varphi} = 1 \quad (26)$$

which is assumed to equal unity. This assumption pins down the lower bound of the Pareto distribution to 0.70588. For calibrating the open economy version of this model, we first of all made the assumption that fixed costs for export and domestic production are equal. The probability for becoming a exporter conditional on successful market entry therefore becomes

$$\varrho = \frac{(1 - G(\varphi_x^*))}{(1 - G(\varphi^*))} = \left( \frac{\varphi^*}{\varphi_x^*} \right)^\gamma = \left( \frac{p(\varphi^*)}{p(\varphi_x^*)} \right)^\gamma = \left( \frac{p(\varphi^*)}{\tau p(\varphi^*)} \right)^\gamma = \tau^{-\gamma} . \quad (27)$$

The average productivity of domestic firms that solely sell their varieties on domestic markets basically remains the same as under autarky and is given by equation (13), where the equilibrium

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<sup>11</sup>Our calibration of the equilibrium market tightness in the U.S. economy is based on the findings of Hall (2005).

<sup>12</sup>The estimate the destruction rate of jobs to be equal 1.4% in France, which gives rise to a market tightness equal to 0.10267.

<sup>13</sup>We set autarky as benchmark for the calibration as in Felbermayr and Prat (2007).

productivity distribution for domestic suppliers and domestic export firms is given by

$$\mu(\varphi) = \begin{cases} \frac{g(\varphi)}{1-G(\varphi^*)} = \frac{\gamma}{\varphi} \left(\frac{\varphi^*}{\varphi}\right)^\gamma & \text{if } \varphi \geq \varphi^* \\ 0 & \text{otherwise} \end{cases} \quad \mu_x(\varphi) = \begin{cases} \frac{g(\varphi)}{1-G(\varphi_x^*)} = \frac{\gamma}{\varphi} \left(\frac{\varphi_x^*}{\varphi}\right)^\gamma & \text{if } \varphi \geq \varphi_x^* \\ 0 & \text{otherwise} \end{cases}$$

respectively. Knowing the equilibrium productivity distribution allows us to rewrite equation (14) as

$$\tilde{\varphi} = \left(\frac{\gamma}{1-\sigma+\gamma}\right)^{\frac{1}{1-\sigma}} \varphi^* \quad \tilde{\varphi}_x = \left(\frac{\gamma}{1-\sigma+\gamma}\right)^{\frac{1}{1-\sigma}} \varphi_x^* \quad (28)$$

for domestic and export suppliers, respectively. The last step is to prepare equation (19) for calibration, which after some rearrangements yields

$$\varphi^* = \left(\left(\frac{\sigma-1}{\gamma+1-\sigma}\right) \left(\frac{(1+n\rho)}{r+\delta}\right) \frac{f}{f_e}\right)^{\frac{1}{\gamma}} \bar{\varphi} \quad (29)$$

and which unambiguously pins down the cutoff productivity level for the domestic sector. The cutoff productivity level for the export regime is then easily found by taking the interrelationship between domestic and export cutoff into consideration, which is given by  $\varphi_X^* = \varphi_D^* \tau \left(\frac{f_X}{f}\right)^{\frac{1}{\sigma-1}}$ . Once both cutoff productivity levels are found, the aggregate average productivity is derived by factoring both values into equation (13). Notice that one can solve for the aggregate average productivity without knowing the mass of active firms  $M$ , since further simplifications allow to write equation (13) in a way that it is independent of the number of active firms.

## 6.2 Results of the Calibration

Now we turn to the outcomes of the calibration exercise. The assumption of equal fixed costs for domestic and foreign supply is maintained for *i*) and *ii*). For scenario *iii*) we relax this assumption and freeze  $\tau$  at the level of 1.5. The last subsection additionally analyzes the effects of an increasing degree of external economies of scale on the effects of trade liberalization. Calibrating the model with these free trade specifications discussed above yields the following results:

**Falling Transport Costs.** One of the main properties in all models that are based on the Melitz framework is that, in the open economy scenario, allowing the iceberg transportation costs to go to infinity yields the same results as under autarky. The plot below proves that

this proposition also holds true for the underlying free trade extension of the model. As can be seen in figure (4), decreasing iceberg transport costs has a decreasing effect on unemployment due to an increasing market tightness. Hence, the aggregated average productivity is rising. To be more precise, the expansion of the export sector is enough to compensate for the shrinking domestic sector. Since labor is a perfect substitute between the domestic and the export sector, those workers who were forced out of the least productive firms that solely serve the domestic market will be rehired by firms with a higher productivity.<sup>14</sup>

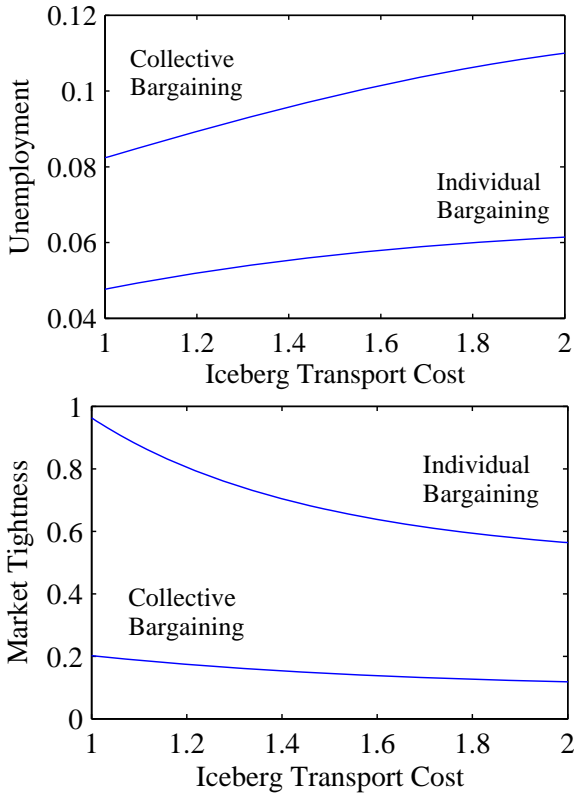


Figure 4: Rising  $\tau$

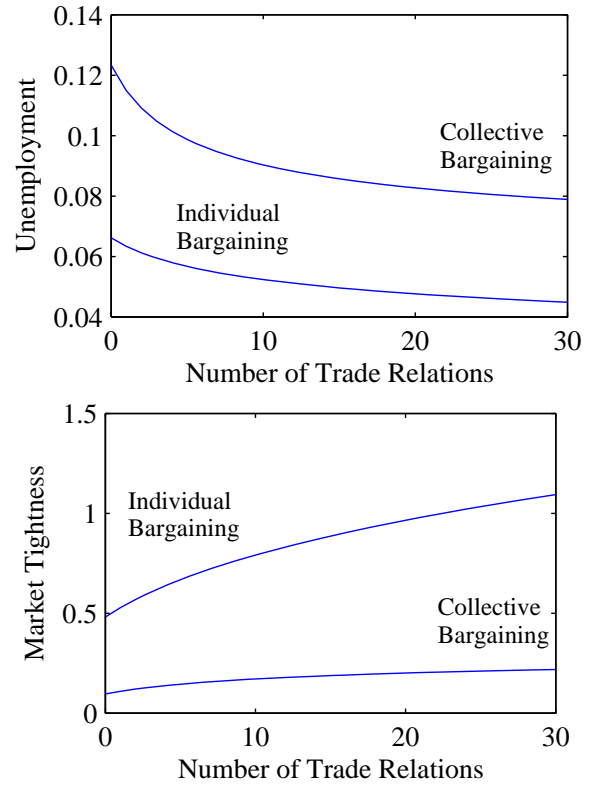


Figure 5: Rising  $n$

Additional to the job turnover between the two different sectors, formerly unemployed workers will be hired in order to satisfy the excess demand for labor. This will diminish the rate of unemployment in both economies, the individual bargaining U.S. economy and the collective

<sup>14</sup>Note that saying anything about the process of reallocation is impossible due to the fact that one can neither partition the workforce according to productivity nor according to wages. Therefore, there is no reason why firms choose a particular worker.

bargaining European economy. Setting iceberg transport costs equal to zero<sup>15</sup> gives rise to the costless free trade scenario where only the most productive firms survive and where all remaining firms engage in international trade. Therefore, this is the case of the highest average productivity and the lowest rate of unemployment possible. This is a highly unrealistic scenario and we therefore concentrate on the case of higher values for  $\tau$ .

The degree of the diminishing effect seems to be similar for both, the individual and collective bargaining setup. Only the locus of the unemployment curve related to collective bargaining is much higher than that for the individual bargaining one. To be more precise, decreasing iceberg transport cost from  $\tau = 2$  to  $\tau = 1$  decreases the rate of unemployment from 11% to 8.237% and 6.14% to 4.77% for collective and individual bargaining, respectively. This is a striking result since proposition 3 states that the effect on equilibrium market tightness is weaker in case of collective bargaining than in case of individual bargaining. Our calibration reveals an even stronger effect of globalization on unemployment in the collective bargaining setup.

To understand this result, recall that the Beveridge Curve is convex. Thus, the lower the equilibrium market tightness, the higher the fear of being unemployed and therefore the stronger the effect of a change in the equilibrium market tightness. This is also reflected in the corresponding plots for the equilibrium market tightness, which ranges from 0.1185 to 0.2019 and from 0.564 to 0.963 for collective and individual bargaining, respectively.<sup>16</sup> Comparing the plots for unemployment and equilibrium market tightness shows that marginal changes in the market tightness translate in relatively high changes in unemployment if the starting value of market tightness is relatively low.<sup>17</sup>

**Rising Number of Trade Relations.** An increasing number of trade relations has exactly the same impact on average productivity as falling iceberg transport costs. For the sake of traceability, iceberg transport costs were frozen on the level  $\tau = 1.5$ .

This is quite intuitive, since a total number of zero trade relations would mean that the economy is closed down to autarky. Trade liberalization due to the establishment of new trade relationships then leads to an increasing average productivity, which induces a rapid decrease in unemployment. Note that the impact of an increasing number of trade relations seems to be

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<sup>15</sup>Which is the case if  $\tau = 1$ .

<sup>16</sup>For values of  $\tau$  between 1 and 2.

<sup>17</sup>The Beveridge curves in both countries also differ due to the different matching functions for Europe and America.



identical to the impact of an decreasing iceberg transport costs. As before, in case of an infinite number of trade relations unemployment converges to approximately 7% in Europe and 3.7% in America.<sup>18</sup> Hence, the calibration results are again in line with the theoretical findings of Melitz (2003), who pointed out that  $\frac{\partial \varphi^*}{\partial n} > 0$  and  $\frac{\partial \varphi_x^*}{\partial n} < 0$  is accompanied by a rise in aggregated average productivity. As in the scenario before, where trade liberalization was triggered by decreasing variable trade costs, an increase in average productivity encourages firms to post more vacancies and therefore leads to a falling rate of unemployment.

**Rising Fixed Costs for Export.** Calibration of the rising  $f_X$  scenario supports our theoretical results insofar that the predicted decreasing cutoff productivity for domestic supply and the predicted increasing cutoff productivity for export supply is present in the calibration results.

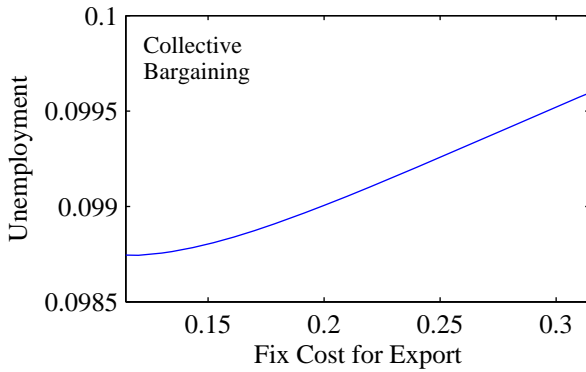


Figure 6: Rising  $f_X$

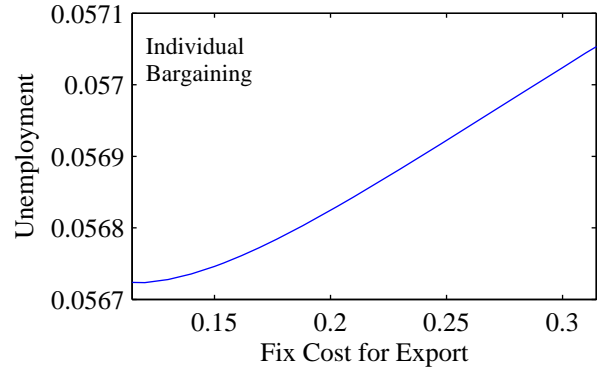


Figure 7: Rising  $f_X$

Accordingly, the average productivity in the export sector rises due to the exit of less productive firms and the average productivity in the domestic supply sector falls due to the entry of less productive firms. The question that arises is whether the average productivity increases or decreases. Finally, the aggregated average productivity is rising in a decreasing  $f_X$ . Thus, the rate of unemployment falls in case of a decreasing fixed costs for export. Again this outcome holds for both bargaining regimes. The plots in Figures (6) and (7) depict the rate of unemployment for the case of rising  $f_X$ , where  $\tau$  was fixed at a level of 1.5 and  $n$  was set equal to 5 for individual and collective bargaining. Finally, at least in our model the effect of a variation in export beachhead costs is negligible. An increase of  $f_X$  from 0.1155 to 0.3155 yields an decrease in unemployment of less than 1%, which is rather weak given the relatively high variation of  $f_X$ .

<sup>18</sup>Compare to figure (4).

## 7 Empirical Evidence on the Unemployment-Openness Nexus

In this section, we use aggregate data to study the empirical relation between openness and the equilibrium rate of unemployment in a panel of 20 rich OECD countries over the years 1982-2004.<sup>19</sup> Before turning to formal econometric analysis, it is worthwhile to look at raw data. Figure ?? shows unweighted averages of the share of imports in GDP and the unemployment rate over time. The openness measure is in current prices, which accounts for the liberalization induced shift in the price of traded relative to non-traded goods present in our theoretical model (see Ghironi and Melitz, 2005). The unemployment rate plotted in the figure is that for the prime-age (25-54 years) labor force. This series suffers least from country-specific peculiarities regarding education and retirement. In our regression analysis, we conduct robustness checks using a host of alternative openness measures and unemployment rates; we also extend back to the seventies, where data availability and quality is more problematic.

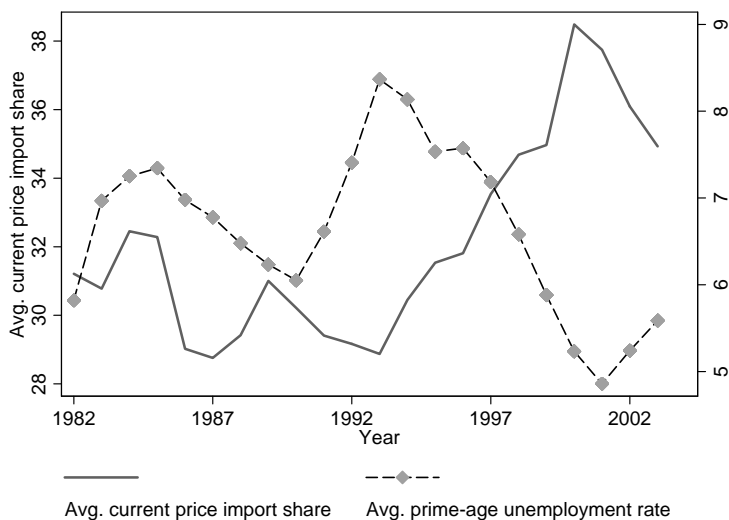


Figure 8: Evolution of openness and unemployment in OECD 20, 1982-2004

Not surprisingly, the rate of unemployment exhibits a strong counter-cyclical pattern, which is less pronounced in the openness measure. The import share shows an upward trend, which is – relative to constant price openness measures – contained due to the secular fall in the price of traded relative to non-traded goods. At a first rough glance, the two series appear

<sup>19</sup>In contrast to micro data, aggregate studies have the advantage that they are able to account for general equilibrium effects.

negatively related. A key challenge in the econometric analysis is to purge the data from business cycle variation, on which our theoretical model is silent.

The established empirical literature on the determinants of equilibrium unemployment provides the tools to deal with business-cycle variation. Bassanini and Duval (2006) – henceforth B&D – offer a recent survey of econometric methods and address the low degree of robustness in results. In this paper, we take the three main empirical strategies described by B&D – pooled OLS, feasible dynamic GLS, and dynamic GMM models – and simply augment the model by some openness measure.<sup>20</sup>

Our results are surprisingly conclusive and – without being a formal test of our theory – consistent with our model. Regardless of exact sample choice, the empirical method, or details of the openness measure, we find a statistically and economically significant conditional correlation between unemployment and openness. Our evidence suggests that the direction of causality is from openness to unemployment. There is also some evidence that the beneficial effect of trade on the unemployment rate is weaker for young unemployed workers and when labor market institutions are “inadequate”.

## 7.1 Benchmark specification, variables, and data sources

Blanchard (2005) discusses the key institutional determinants of equilibrium unemployment. The data set compiled by B&D allows to control for most of those drivers. In our baseline regression (similar to table 1.2 of B&D), we include (i) the average replacement rate, (ii) the tax wedge, (iii) union density, (iv) employment protection legislation (EPL), (v) product market regulation (PMR), and (vi) a dummy for highly corporatist industrial relations. We control for business cycle variation using the output gap, which measures the deviation of actual from potential output as a percentage of potential output, and a set of macroeconomic shocks: TFP-shocks, terms of trade shocks, interest rate shocks, and labor demand shocks.<sup>21</sup>

We augment the model with various measures of trade openness; all of them are fairly standard: we use the current price share of total imports in GDP, of total trade (imports plus exports) in GDP, and of trade in manufactured goods in GDP. We also use the constant price

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<sup>20</sup>Including openness into standard cross-sectional unemployment regressions seems an obvious extension. However, the survey conducted by B&D does not discuss any such study.

<sup>21</sup>The construction of the output gap and of macroeconomic shocks follows Blanchard and Wolfers (2000) and is described in great detail in B&D, pp. 112-113.

share of total trade in GDP and the Alcalá-Ciccone (2004) measure of openness. Those data are taken from the World Development Indicators (WDI, version 2006) or the Penn World Tables (PWT, version 6.1). The appendix provides more detail on data sources, summary statistics, and the countries included.

The dependent variable usually is the harmonized unemployment rate defined over the total labor force provided by the OECD. We also show results using youth and prime-age unemployment rates as dependent variables.

## 7.2 Empirical methodology

All regression models include country and year fixed effects to account for unobserved heterogeneity and to control for common shocks in a non-parametric way. We work with three different setups, which have all been extensively used in the established literature (see B&D for a survey).<sup>22</sup>

**Method 1: Least squares dummy variables (LSDV).** The preferred method of B&D is to run OLS on a pooled cross-section of countries, including country and year fixed effects. Standard errors are robust to country-level clustering. Dynamics remain unmodeled.

**Method 2: Feasible generalized least squares (FGLS).** In a recent paper, Nickel, Nunziata, and Ochel (2005) – henceforth NNO – use a dynamic equation, with a first-order lag of the unemployment rate on the right-hand-side. They add country dummies, year dummies, and country specific trends. NNO use a dynamic FGLS regression allowing for heteroskedastic errors and country-specific first order serial correlation.<sup>23</sup>

**Method 3: Generalized method of moments (GMM).** Both, B&N (in their preferred specification) and NNO treat labor market institutions and the output gap as exogenous. In

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<sup>22</sup>The literature contains a number of alternative estimation strategies beyond the ones used in the present paper. We have experimented with some techniques, for example the *difference-in-difference* approach, with results very much in line to OLS with country dummies.

<sup>23</sup>The choice of fixed rather than random country effects in methods 1 and 2 reflects the view that country effects are unlikely to be independent from other explanatory variables included in the estimated equation – in which case random-effects FGLS estimators would yield inconsistent estimates.

principle (though not in our theory), trade openness may be endogenous to labor market outcomes. For example, governments may resort to (unobservable) protectionist policies affecting openness in order to counter adverse unemployment shocks. For the countries included in our sample, such policies are heavily constrained by international trade agreements. Nevertheless, we present results from GMM techniques, which allow treating openness (along with the output gap) as endogenous variables.<sup>2425</sup>

We use both, the GMM-dif estimator developed by Arellano and Bond (1991) and the GMM-sys estimator of Blundell and Bond (1998). In both cases, the unemployment equation is first-differenced, which removes unobserved cross-country heterogeneity. GMM-dif treats the model as a system of first-differenced equations, one for each time period. The equations differ only in their instrument/moment condition sets. Endogenous variables in first differences are instrumented with suitable lags of their own levels.

A problem with the *GMM-dif* estimator is that lagged levels are often poor instruments for first differences. The *GMM-sys* estimator adds the original equations in levels to the system, thereby increasing the number of moment conditions and hence efficiency. In the level equations, endogenous variables in levels are instrumented with suitable lags of their own first differences. The main necessary assumption for this augmented estimator is that the unobserved country effects are not correlated with changes in the error term. All methods except the *GMM-dif* approach exclusively draw on within variation to identify the estimated coefficients.

### 7.3 Baseline results

We first focus on two measures of openness: current price trade openness and the current price share of imports in GDP. Table A reports the results.

**Least squares dummy variables estimation.** Column (1) reproduces the baseline regression of Table 1.2., column (1) in B&N.<sup>26</sup> Labor market institutions turn out to affect the equilibrium unemployment rate as in B&N: a higher average replacement ratio, a larger tax wedge,

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<sup>24</sup>Also labor market institutions might be endogenous, see B&D for a discussion. However, given the limited size of our panel, instrumenting *all* right-hand-side variables is not feasible.

<sup>25</sup>In principle, rather than using GMM, it would be desirable to have an adequate instrument for openness. We discuss such an instrument in the extensions.

<sup>26</sup>B&N take out Germany, Sweden, and Finland 1990-91 from the sample. We follow in this practice. Results are virtually identical with those observations included.

and more stringent product market regulation drive up unemployment, while a high degree of corporatism and stronger employment protection legislation reduce it. Stronger EPL appears to reduce unemployment.<sup>27</sup> In column (2) we additionally include the current price openness measure. Labor market variables change only marginally, with the exception of corporatism. Increased openness reduces unemployment in a statistically and economically significant way: a one-standard-deviation increase in current price trade openness reduces the unemployment rate by 1.46 percentage points. This is larger than the effect of the replacement rate (0.85 points), high corporatism (0.50 points) or PMR (0.76 points), comparable to EPL (1.48 points), but lower than the effect of the tax wedge (2.43 points). The adjusted  $R^2$  of the regression is 0.88. Regressing the unemployment rate on the output gap and country dummies (results not shown) achieves an adjusted  $R^2$  of 0.80; adding the labor market variables (column (1)) improves the  $R^2$  to 0.87. Hence, openness is not a key driver of the unemployment rate – but standard labor market institutions are not much more important, neither.

Column (3) uses the current value import share in GDP as an alternative measure of trade openness. Compared to column (2), most coefficients change very little. The effect of the import share on the unemployment rate is accurately measured. A one-standard-deviation increase results in a reduction of the unemployment rate by 1.89 percentage points. Hence, it does not seem that increased import penetration is associated to adverse labor market effects; quite the contrary.

Column (4) adds a battery of macroeconomic shocks to the baseline regression of column (2), again following B&D. Adjusted  $R^2$  and  $F$ -statistic improve, the replacement rate loses its effect, but the current price trade openness continues to reduce unemployment similar to the finding in columns (2) and (3).

**Feasible generalized least squares estimation.** Columns (5) to (7) use the methodology employed by NNO, but without including interaction terms between shocks and institutional variables. As in NNO, regressions include country-specific trends. All coefficients shown refer to short-run effects. For the interesting openness variable, we also show the long-run.

Strikingly, compared to the LSDV model used in column (4), the coefficients on labor market variables now exhibit a very different sign pattern; only the sign on EPL stays the same. In

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<sup>27</sup>Blanchard (2005) offers a survey of the empirical and theoretical literature. The effect of the replacement rate is consistent with our model; we do not have predictions on the other variables. See Felbermayr and Prat (2007) on the role of product market regulation in a similar theoretical setup. Theory typically predicts an ambiguous effect of EPL.

contrast, the coefficients on macroeconomic variables – the output gap and shocks – look similar to those obtained in column (4), in particular when using long-run values. Thus, the low robustness of labor market institutions does not carry over to those variables.<sup>28</sup> This makes us confident that the GLS estimates are meaningful nevertheless. Turning to the coefficients on the two openness measures, we find that both trade openness and the import share are positively associated to the rate of unemployment. The short-run effects are similar in magnitude to those found in column (4). However, in the long-run, the effect of openness on the rate of unemployment is about twice as large: a one-standard-deviation increase in the trade or import share lowers unemployment by 3.2 and 3.1 percentage points, respectively. The larger long-run effects are not surprising, given the short time span (22 years) of the panel. Again, comparing column (5) to (6) and (7), the introduction of openness into the regression has only a very minor effect on the estimates of labor market variables.

**Generalized method of moments estimation.** We instrument our openness measures and the output gap. To keep the number of instruments low,<sup>29</sup> we create one instrument for each variable and lag distance, rather than one for each time period, variable, and lag distance. The Hansen statistic provides a test of over-identifying restrictions. The model is rejected if the statistic is significant. Arellano-Bond statistics AR(1) and AR(2) test the autocorrelation of the first difference of the residuals at order 1 and 2. The model is rejected if evidence of autocorrelation is found at order 2. In most regressions, the data requires two lags of the dependent variable to avoid higher-order autocorrelation in the error terms. Generally, we use the one-step estimators.<sup>30</sup>

Columns (8) and (10) report the results of GMM-dif, columns (11) to (13) of GMM-sys. Regarding labor market institutions, only the high corporatism dummy turns out significant across all models. With GMM-sys, EPL and PMR turn out significant, too, confirming the signs found in columns (1) and (5). Our openness measures – current price trade openness and the import share – come out significant in all models, with parameter estimates somewhat larger still than those found with FGLS. Therefore, it seems that endogeneity bias is not a big issue in the FGLS models. However, given wide-spread concerns on the sensitivity of dynamic GMM panel models,

<sup>28</sup>On the low robustness of cross-country unemployment regressions, see Baker et al. (2004).

<sup>29</sup>When the number of instruments is large relative to the number of observations, GMM estimates tend to be biased towards OLS.

<sup>30</sup>Two-step estimates of the standard errors are asymptotically more efficient, but tend to be severely downward biased (Bond and Blundell, 1998).

we consider our GMM results as robustness checks rather than full-fledged regression exercises of their own.

## 7.4 Robustness checks and extensions

**Youth, prime-age, and total unemployment rates.** Table 4 runs the regressions discussed in Table A for different unemployment rates (without including macro shocks in any regression to minimize the loss of observations due to fewer data on unemployment rates). B&D provide the unemployment rate amongst young individuals in the labor force (aged 15 to 24) and for prime age individuals (aged 24 to 54). There is no data on pre-retirement ages (55-64) available. Column (1) in Table 4 reports the effect of openness on prime age unemployment, column (3) shows the effect on the total unemployment rate. Results are similar in terms of magnitudes and statistical significance. Turning to column (2), we do not find robust evidence for a beneficial effect of openness on youth unemployment. In the LSDV and FGLS models, where the openness measure is not instrumented, the effect is fairly large and statistically significant. However, in both GMM models, the effect does not survive instrumentation of the openness measure and the output gap. It seems that trade openness may well make hiring workers more attractive for efficient firms, but it does little *per se* to bring marginal workers into employment.

**Alternative openness measures.** Table 5 uses different measures of openness as determinants of the total unemployment rate. It shows the long-run effects of increasing openness by one standard deviation. The first line reports on the constant price trade openness measure. This measure reports the quantity margin of openness, holding prices constant at a base year. The economic impact of trade is likely to depend also on the price margin; this is why we prefer current price measures. Nevertheless, it is comforting that the overall picture remains intact: higher openness, lower unemployment.

The second line is a current price measure again, but it excludes trade in services. Again, there is no reason to believe that this measure is by any means superior to one that is based on total trade. However, results do not depend on including or excluding services. Finally, the third line uses the ‘real’ openness measure proposed by Alcalá and Ciccone (2004) for use in cross-country regressions with TFP as the dependent variable. They argue that their measure is superior to the standard current price openness measure when there are non-traded goods and a trending real exchange rate. Since our theoretical channel is about the effect of trade on aggregate productivity, the real openness measure may be relevant: however, with the exception of GMM-sys,



the beneficial effect of trade openness on the unemployment rate remains.

**Longer time-span, and five-year averaged data.** Table 6 extends our sample of 20 OECD countries to a longer period, namely 1970-2003 ( $T = 34$ ). including the period 1970-1981, when unemployment increased rapidly in all of the countries sampled. Moreover, the larger time dimension should make GMM results less prone to specification error and allows the use of a larger instrument matrix. Unfortunately, some of the labor market variables that B&D have found important are not available for that longer time period. In particular, we lack information on the tax wedge, on EPL and PMR. The results indicate that the beneficial effect of openness on unemployment is robust to that longer time span. Point estimates are slightly smaller in absolute value than in the shorter sample. However, the standard deviation of both the current price trade openness and the import share measure is somewhat larger, so that, quantitatively, the results are very similar to Table A.

We have also checked whether our results hold when we follow the practice in dynamic panel growth regressions and work with five-year averages rather than with yearly data. This procedure is an additional way to eliminate business cycle variation. The estimates do not change much, in particular when using the LSDV and FGLS methods. In the case of GMM, the reduced time-dimension has lowers the size of the matrix of instruments. While standard errors are somewhat larger than in the yearly panel, the sign and size pattern of estimated coefficients does not change.

**How the bargaining regime conditions the openness-unemployment nexus.** Table 7 reports the results of regressions, based on the LSDV model of B&N. All models contain the full list of labor market covariates, along with country and time dummies, and macro-economic variables. In each line, a different labor market variable is interacted with current price openness (left panel) or with the share of imports in GDP (right panel). In all specifications, the direct effect of openness is negative, as in our benchmark models. Direct effects of the labor market variables considered in each line are not always statistically significant. However, the interaction term comes out positive and statistically significant in all models but one. Hence, when labor market regulation becomes stricter, the unemployment-reducing effect of trade openness becomes smaller.

We compute the total unemployment effect of a one-standard-deviation increase in openness, evaluating the respective labor market variable at its sample mean. We find negative effects

throughout. Hence, trade liberalization reduces unemployment, even when the quality of labor market regulation is only average. The overall effect remains sizable, with the degree of union coverage a notable exception. This is nicely in line with our theoretical model: the more widespread collective bargaining is, the more of the productivity gain from international trade goes into an increase of the real wage and the less into a reduction of the unemployment rate.

**An alternative way to address endogeneity** An obvious strategy in our cross-country context is to use the Frankel and Romer (1999) (henceforth: F&R) openness instrument, which builds on countries' geographical distance from their trading partners. By construction that measure is orthogonal to any economic variable, such as per capita income or – in our case – the unemployment rate. Unfortunately, this instrument is of no use in a panel, due to the time-invariant nature of geography. A purely cross-sectional analysis suffers from the low number of observations ( $N = 20$ ) and from the difficulty to properly control for business cycle conditions without a time dimension.

We have nevertheless conducted the following exercise. (i) Run a standard B&N regression of unemployment on labor market and macro variables (in particular the output gap), omitting the openness measure and country fixed effects. (ii) Compute the residuals of this regression and average over time. (iii) Regress those residuals on openness, using the F&R instrument. The residuals are (hopefully) free from business cycle variation and changes in labor market institutions. If the residuals (predicted minus actual unemployment rates) are *positively* affected by our openness measures, then this purely cross-sectional exercise reproduces our panel findings. If this relationship survives instrumentation, then we have evidence of a causal effect.

2SLS regression of the average residual on the import share instrumented à la F&R gives an  $R^2$  of 10.81 and a coefficient 0.0467 with a (robust) standard error of 0.0213.<sup>31</sup> Very similar results emerge when using alternative openness measures (since they correlate equally well with the F&R instrument). This is comforting. However, results are somewhat sensitive to the existence of a group of outliers (Netherlands, Belgium, and Ireland). Moreover, including geographical variables (area, population) in the second stage regression destroys significance (but not the sign) of the effect (which is not surprising given the small sample size  $N = 20$ ).<sup>32</sup>

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<sup>31</sup>The OLS regression of the average residual on the import share gives a coefficient of 0.0395 with a (robust) standard error of 0.0190 and an  $R^2$  of 11.17.

<sup>32</sup>We have also experimented with regressing openness on estimates of country fixed effects obtained in the typical B&N regression (with no openness indicator) and using the F&R instrument. Results are comparable to the strategy described in the text.

## 8 Conclusions

Bringing together two important established but hitherto unrelated models in the trade and labor literatures – the Melitz (2003) model of trade with heterogeneous firms, and the Pissarides (2000) search and matching approach to unemployment – this paper shows that the selection effect of trade has a beneficial impact on employment. This prediction turns out to be robust to various assumptions about the wage setting mechanism and is reached in a surprisingly tractable and recursive framework. Our calibration exercise shows that the reduction in the unemployment rate is numerically non-trivial. Using aggregate cross-country data, we also address the openness-unemployment nexus empirically, and find a strong and robust negative relation between trade and unemployment, in line with our theory.

We want to close this paper with a number of caveats. Our approach focuses on long-run equilibria. This precludes the analysis of potentially interesting short-run adjustments. Most empirical studies on the interaction between trade liberalization and labor turnover capture short to medium-run correlations (e.g., Naercio and Muendler, 2006), so that our model has little to say relative to their results. Moreover, as argued in Davidson and Matusz (2006), positive long-run effects have to be weighed against potential short-run losses. We therefore plan to address a full-fledged analysis of adjustment dynamics in future work.<sup>33</sup>

Our conclusion is also limited to the impact of multilateral trade liberalization amongst symmetric countries. Hence, we cannot say much about the recent surge in bilateral trade treaties or, even more importantly, about the effect on employment of trade liberalization with emerging countries such as China or India. We therefore believe that the most promising direction for further research would be to follow Falvey et al. (2006) in order to extend our model to cases where countries differ with respect to size, productivity levels and institutions.

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<sup>33</sup>In the Melitz model, average productivity overshoots initially (Chaney, 2006), which suggests positive short-run effects. However, in our model this effect is counteracted by labor market dynamics where job destruction is instantaneous while job creation takes time. The overall short-run effect will therefore be ambiguous.

## Appendix

### A Tables

Table 2: Summary statistics: OECD 20, 1982-2003. N=440

Variable	Mean	Std. Dev.	Source
Total unemployment rate (%)	7.7491	4.1785	B&D (2006)
Unemployment rate, age 15-24 (%)	0.1532	0.0848	B&D (2006)
Prime age unemployment rate, age 24-54 (%)	6.6394	3.5023	B&D (2006)
Current price trade openness: (exports + imports) / 2 GDP	32.9234	16.0892	PWT 6.1
Current price import share: imports / GDP	32.1287	15.2073	WDI 2006
Constant price trade openness: (exports + imports) / 2 GDP	30.7081	16.4853	PWT 6.1
Current price trade openness, excl. services: (exports + imports) / 2 GDP	26.8627	14.2232	WDI 2006
Real openness (Alcala and Ciccone, 2004)	68.9414	37.5065	PWT 6.1
Tax wedge (%)	28.7460	8.9449	B&D (2006)
Average unemployment benefit replacement rate (%)	29.7143	12.5580	B&D (2006)
Union density (%)	39.8867	20.7143	B&D (2006)
EPL (employment protection legislation), index increases in strength of protection	2.0832	1.0912	B&D (2006)
PMR (product market regulation; index increases in strength of regulation)	3.8144	1.2822	B&D (2006)
High corporatism	0.5545	0.4976	B&D (2006)
Output gap (%)	-0.9219	2.5673	B&D (2006)
TFP shock	-0.0015	0.0225	B&D (2006)
Terms of trade shock	-0.0430	0.0703	B&D (2006)
Interest rate shock (%)	4.6061	2.2513	B&D (2006)
Labour demand shock	0.0325	0.0624	B&D (2006)

Countries included: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Switzerland (CHE), Germany (GER), Denmark (DNK), Spain (ESP), Finland (FIN), France (FRA), Great Britain (GBR), Ireland (IRL), Italy (ITA), Japan (JPN), Netherlands (NLD), Norway (NOR), New Zealand (NZL), Portugal (PRT), Sweden (SWE), and the United States (USA).

Table 3: The effect of openness on the unemployment rate, 1982-2003

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	
	none		LSDV		none		FGLS		none		GMM-diff		GMM-sys	
	none	trade	imports	trade	none	trade	imports	none	trade	imports	none	trade	imports	
Openness measure														
L1.unemployment rate	0.298*** (0.028)	0.284*** (0.026)	0.282*** (0.026)	0.198*** (0.029)	-0.0410** (0.017)	-0.0363** (0.016)	-0.0340** (0.017)	0.0523 (0.066)	0.0644 (0.056)	0.0506 (0.049)	0.170 (0.12)	0.0907 (0.10)	0.000363 (0.083)	
Avg. replacement rate (%)	0.0790*** (0.018)	0.0633*** (0.018)	0.0610*** (0.019)	0.00346 (0.019)	-0.0634*** (0.016)	-0.0589*** (0.016)	-0.0589*** (0.016)	0.0670 (0.078)	0.0125 (0.068)	-0.0614 (0.053)	0.0482 (0.081)	0.0317 (0.081)	-0.0144 (0.082)	
Union density (%)	-0.0106 (0.021)	-0.0146 (0.021)	-0.0141 (0.021)	-0.00915 (0.022)	0.0213 (0.023)	0.0307 (0.022)	0.0392 (0.022)	-0.0210 (0.062)	-0.00242 (0.070)	-0.0182 (0.070)	-0.0330 (0.057)	-0.0203 (0.052)	-0.00178 (0.047)	
EPL	-1.408*** (0.34)	-1.462*** (0.35)	-1.532*** (0.35)	-1.645*** (0.33)	-0.553** (0.23)	-0.493** (0.22)	-0.544** (0.22)	-0.717 (0.94)	-0.745 (0.83)	-0.495 (1.09)	-1.536 (1.04)	-2.159*** (0.74)	-2.295*** (0.74)	
PMR	0.509** (0.22)	0.555*** (0.21)	0.563*** (0.21)	0.637*** (0.18)	0.0391 (0.12)	-0.0922 (0.11)	-0.147 (0.09)	0.620 (0.69)	0.592 (0.59)	0.694 (0.86)	1.253 (1.04)	1.443* (0.86)	1.546** (0.78)	
High corporatism (1/0)	-1.526*** (0.40)	-1.154*** (0.40)	-1.220*** (0.39)	-1.175*** (0.39)	-0.230 (0.29)	-0.380 (0.26)	-0.395 (0.26)	-3.169** (1.30)	-2.397** (0.97)	-1.904** (0.90)	-4.369** (1.92)	-3.333** (1.45)	-2.478** (1.23)	
Output gap (%)	-0.541*** (0.039)	-0.537*** (0.039)	-0.516*** (0.039)	-0.719*** (0.046)	-0.469*** (0.026)	-0.465*** (0.025)	-0.445*** (0.026)	-0.238 (0.15)	-0.259** (0.13)	-0.317*** (0.11)	-0.251** (0.12)	-0.280*** (0.097)	-0.301*** (0.091)	
TFP shock				36.14*** (3.93)	16.23*** (2.13)	16.03*** (2.07)	14.93*** (2.10)	-6.481 (10.5)	1.506 (7.78)	10.71 (7.92)	-6.032 (11.9)	0.335 (7.92)	7.099 (7.15)	
Terms-of-trade shock				14.75*** (2.69)	6.637 (2.07)	7.016*** (2.50)	6.781*** (2.47)	10.17** (5.13)	8.436* (4.83)	11.09** (5.14)	15.94* (9.64)	12.67 (9.17)	13.01 (9.27)	
Real interest rate shock				0.217*** (0.063)	0.0168 (0.015)	0.00732 (0.014)	0.0267* (0.014)	0.00729 (0.057)	0.0438 (0.050)	0.147*** (0.055)	-0.0551 (0.080)	-0.0135 (0.063)	0.118** (0.059)	
Labor demand shock				11.15*** (2.41)	10.14*** (2.82)	9.021*** (2.58)	7.070*** (2.65)	-3.207 (17.6)	13.86 (16.7)	24.23* (14.4)	-9.039 (12.9)	-0.895 (10.7)	8.791 (12.5)	
Observations	440	440	440	397	397	397	397	374	374	374	397	397	397	
Adj. R2	0.867	0.881	0.888	0.923			15180	146.5	465.6	413.6	891.2	92.60	346.1	
F / Chi 2	23.78	27.23	28.11	30.18	14623	15170	15180	1	1	1	1	1	1	
Hansen p-value								0.154	0.035	0.00629	0.181	0.0485	0.00172	
AR(1) p-value								0.791	0.739	0.653	0.926	0.979	0.758	
AR(2) p-value														

Notes: All specifications include year dummies and account for country fixed effects. Sample: OECD 20 (1982-2003). Robust standard errors in brackets. \*, \*\*, \*\*\* denotes statistical significance at the 10, 5, 1 percent level. FGLS includes country-specific trends and allows for 1st-order serial autocorrelation in error terms. GMM: One-step GMM robust estimates. The error term is modeled as an ARMA process with an AR(1) component. Openness and the output gap are treated as endogenous variables. The Hansen-Sargan statistic provides a test of overidentifying restrictions. The model is rejected if the statistic is significant. Arellano-Bond statistics test the autocorrelation of the first difference of the residuals at order 1 and 2 and are normally distributed under the null. The model is rejected if evidence of autocorrelation is found at order 2.

Table 4: The effect of openness on different unemployment rates, 1982-2003

		(1)	(2)	(3)
		Prime age (24-54)	Youth (15-24)	All (15-64)
LSDV	Trade openness	-0.0810*** (0.0190)	-0.100*** (0.036)	-0.0794*** (0.0210)
	Import share	-0.1090*** (0.0210)	-0.189*** (0.042)	-0.1160*** (0.0230)
FGLS	Trade openness	-0.1778*** (0.0449)	-0.3131*** (0.0687)	-0.2002*** (0.0422)
	Import share	-0.1786*** (0.0423)	-0.2783*** (0.0676)	-0.2032*** (0.0431)
GMM-dif	Trade openness	-0.2196*** (0.0835)	0.0561 (0.2708)	-0.2648*** (0.0967)
	Import share	-0.2373*** (0.0865)	-0.0381 (0.2653)	-0.3300*** (0.1114)
GMM-sys	Trade openness	-0.2611* (0.1350)	-0.14501 (0.1839)	-0.2295** (0.0967)
	Import share	-0.2220*** (0.0829)	-0.1298 (0.2009)	-0.2909** (0.1106)

Notes: Each cell reports results of one regression. Same specifications as in Table 3. Each regression includes additional covariates, country fixed effects (where applicable), year fixed effects, and specific country trends (where applicable) as in the benchmark regressions. LSDV refers to least squares dummy variables (Bassanini and Duval, 2006); FGLS refers to feasible generalized least squares (Nickel et al., 2005), GMM-sys is the Blundell and Bond (1998) system GMM estimator. TMM-dif is the Arellano and Bond (1991) estimator. All specifications include country and year dummies and allow for heteroscedastic errors. FGLS includes country specific linear trends and allows for first order serial correlation in the errors. The table shows long-run effects. \*\*\*, \*\*, \* denote statistical significance at the 1,5,10 percent level. Robust standard errors in brackets.

Sample: 20 OECD countries, 1980-2003, as described in the text. N=440 for LSDV and GMM-sys, N=420 for FGLS).

Dependent variable differs across columns. Column (1) uses the prime age unemployment rate (ages 25-64), column (2) the youth unemployment rate (ages 15-24)

Table 5: The effect of different openness measures on unemployment rates, 1982-2003

	(1) LSDV	(2) FGLS	(3) GMM-dif	(4) GMM-sys
Constant price trade openness	-2.0771 *** (0.3132)	-3.4487 * (0.8539)	-3.6251 *** (0.9924)	-3.7042 * (1.9667)
Current price trade openness (excl. Services)	-1.4181 *** (0.3556)	-1.1336 *** (0.6102)	-2.3212 ** (1.1009)	-3.1462 * (1.7921)
Alcala-Ciccone real openness	-1.7553 *** (0.3226)	-1.8191 *** (0.4838)	-3.2443 *** (1.0427)	-2.2466 (1.8341)
Current price trade openness	-1.4601 *** (0.3218)	-3.2211 *** (0.6500)	-4.2604 *** (1.4480)	-3.6924 *** (1.6893)
Current price import share	-1.8857 *** (0.3346)	-3.0901 *** (0.6113)	-5.0184 *** (1.3823)	-4.4238 *** (1.5496)

Notes: Each coefficient corresponds to a separate regression. Table shows long-run effects of a one-standard-deviation increase in the respective openness measure on the total rate of unemployment. Sample: 1982-2003. All regressions include controls for labor market institutions, output gap, macroeconomic shocks, time dummies, country fixed effects (where applicable) and country specific time trends (where applicable). For further detail see Table 3.

Table 6: The effect of openness on the unemployment rate, long panel 1970-2003

Openness measure	(1) LSDV		(3) FGLS		(5) GMM-dif		(7) GMM-sys	
	trade	imports	trade	imports	trade	imports	trade	imports
L1.unemployment rate			0.665*** (0.025)	0.659*** (0.025)	1.032*** (0.069)	1.019*** (0.066)	1.051*** (0.066)	0.852*** (0.082)
L2.unemployment rate					-0.253*** (0.057)	-0.251*** (0.054)	-0.255*** (0.055)	-0.241*** (0.066)
Openness	-0.0596** (0.027)	-0.109*** (0.028)	-0.0772*** (0.020)	-0.0968*** (0.019)	-0.0610*** (0.012)	-0.0731*** (0.015)	-0.0569*** (0.011)	-0.0791* (0.042)
Long-run effect			-0.2304	-0.2839	-0.2785	0.3151	-0.2789	-0.2033
Avg. replacement rate (%)	-0.0128 (0.014)	-0.0165 (0.014)	-0.0303*** (0.011)	-0.0257** (0.011)	-0.00216 (0.0071)	-0.00320 (0.0072)	-0.00149 (0.0071)	0.0463 (0.040)
Union density (%)	0.0229 (0.016)	0.0226 (0.016)	0.00318 (0.017)	0.00782 (0.017)	-0.00326 (0.0078)	-0.00257 (0.0096)	-0.00302 (0.0067)	-0.0276 (0.039)
High corporatism (1/0)	0.0586 (0.29)	0.103 (0.29)	-0.00750 (0.22)	-0.0294 (0.21)	0.0352 (0.13)	0.0243 (0.14)	0.0146 (0.14)	-0.674 (0.67)
Output gap (%)	-0.763*** (0.050)	-0.747*** (0.050)	-0.357*** (0.026)	-0.345*** (0.026)	-0.188*** (0.043)	-0.176*** (0.043)	-0.184*** (0.041)	-0.147 (0.093)
TFP shock	40.75*** (4.67)	40.84*** (4.65)	10.94*** (2.19)	10.58*** (2.17)	-0.565 (2.71)	-0.664 (2.67)	-0.702 (2.69)	-9.403 (9.00)
Terms-of-trade shock	6.422** (3.10)	8.551*** (3.13)	4.530** (1.88)	6.577*** (1.95)	3.083** (1.42)	4.387*** (1.42)	2.481* (1.37)	16.61** (8.36)
Real interest rate shock	0.136*** (0.032)	0.141*** (0.031)	0.0197* (0.012)	0.0264** (0.012)	0.0227 (0.014)	0.0315** (0.013)	0.0203 (0.014)	-0.0245 (0.042)
Labor demand shock	3.344 (2.46)	1.870 (2.40)	3.394** (1.67)	2.736* (1.65)	-0.395 (1.51)	-0.941 (1.49)	-0.229 (1.36)	-8.794 (6.23)
Observations	560	560	560	560	526	526	549	549
Adj. R2	0.870	0.873						
F / Chi 2	28.43	28.58	15921	15957				
Hansen p-value					1	1	1	1
AR(1) p-value					0.000521	0.000515	0.000529	0.00180
AR(2) p-value					0.950	0.847	0.900	0.226

Notes: This table reports regressions similar to those in Table 3. The only differences lie in the sample size, which here extends back in time (1970-2003) and in the omission of some labor market variables, which are not available over this period. See notes to Table 3 for details on the estimation. The GMM estimates make use of the full instrument matrix: this efficiency gain is possible due to the longer time dimension of the panel (T=34).



Table 7: How labor market variables condition the effect of openness on the unemployment rate, 1982-2003

	Current price trade openness				Current price import share			
	direct effects		interaction	Effect of 1-std.dev. increase in openness	direct effects		interaction	Effect of 1-std.dev. increase in openness
	trade openness	labor market variable			trade openness	labor market variable		
Tax wedge	-0.146*** (0.024)	0.125*** (0.043)	0.00342*** (0.0010)	-0.72	-0.174*** (0.025)	0.160*** (0.044)	0.00273*** (0.0010)	-1.40
Replacement ratio	-0.122*** (0.043)	0.0384 (0.038)	0.000927 (0.0012)	-1.89	-0.142*** (0.044)	0.0491 (0.038)	0.000531 (0.0012)	-2.09
Union density	-0.226*** (0.039)	-0.135*** (0.040)	0.00395*** (0.0010)	-1.72	-0.240*** (0.044)	-0.118*** (0.041)	0.00338*** (0.0011)	-2.09
EPL	-0.137*** (0.025)	-2.528*** (0.67)	0.0406** (0.019)	-0.79	-0.167*** (0.026)	-2.314*** (0.63)	0.0317* (0.018)	-1.47
PMR	-0.133*** (0.021)	-0.0858 (0.33)	0.0169*** (0.0059)	-1.00	-0.172*** (0.023)	-0.108 (0.30)	0.0183*** (0.0056)	-1.44
High corporatism	-0.149*** (0.032)	-2.726*** (0.76)	0.0528** (0.025)	-1.85	-0.170*** (0.032)	-2.695*** (0.77)	0.0461* (0.023)	-1.27
Union coverage	-2.209*** (0.46)	-1.460*** (0.40)	0.0325*** (0.0070)	-0.46	-2.250*** (0.43)	-1.535*** (0.39)	0.0326*** (0.0066)	-0.95

Notes: The table shows results of 14 LSDV regressions; the left panel uses the current price trade openness, the right panel uses the current price import share as openness measure. Each line interacts the respective openness measure with a specific feature of the labor market compact. All regressions contain the other labor market variables, as well as country and year fixed effects, and the output gap. Robust standard errors in brackets. \*, \*\*, \*\*\* denote statistical significance at the 1, 5, 10 percent level. For comparison: the effect of an increase in openness under absence of interactions is -1.72 percentage points for overall trade openness and -2.09 percentage points for the import share.

## B Proofs

**Proof of Proposition 1.** To solve the surplus-splitting rule (8), notice that the optimality condition (5) does not vary with the level of the control variable  $v_I$ . Hence, the optimal firm size remains constant through time, so that  $l_I = l'_I$ . This condition and the envelope theorem enable us to rewrite (6) as

$$\frac{\partial J_I(l_I, \varphi)}{\partial l_I} = \left( \frac{1}{r+s} \right) \left[ \frac{\partial R(l_I; \varphi)}{\partial l_I} - w_I(l_I, \varphi) - \frac{\partial w_I(l_I, \varphi)}{\partial l_I} l_I \right].$$

Reinserting this expression together with  $E_I(\varphi) - U_I = (w_I(l_I, \varphi) - rU_I)/(r+s)$  into (8) yields

$$\begin{aligned} w_I(l_I, \varphi) &= \beta \frac{\partial R(l_I; \varphi)}{\partial l_I} + (1-\beta)rU_I - \beta \frac{\partial w_I(l_I, \varphi)}{\partial l_I} l_I \\ &= \beta \left( \frac{\sigma-1}{\sigma} \right) \left[ \frac{Y_I}{M_I^\eta} (1 + I(\varphi)n\tau^{1-\sigma}) \right]^{1/\sigma} \varphi^{\frac{\sigma-1}{\sigma}} l_I^{-\frac{1}{\sigma}} + (1-\beta)rU_I - \beta \frac{\partial w_I(l_I, \varphi)}{\partial l_I} l_I. \end{aligned} \quad (30)$$

Equation (31) is a linear differential equation in  $l_I$ . One can verify by direct substitution<sup>34</sup> that

$$w_I(l_I, \varphi) = (1-\beta)rU_I + \beta \left( \frac{\sigma}{\sigma-\beta} \right) \frac{\partial R(l_I; \varphi)}{\partial l_I} \quad (31)$$

solves (31). Equation (31) is the counterpart of the *Wage* curve in the standard search-matching model. The *Job Creation* curve is derived reinserting the demand function (2) into (31) and differentiating the resulting equation with respect to  $l_I$

$$\frac{\partial w_I(l_I, \varphi)}{\partial l_I} l_I = -\frac{1}{\sigma} \left[ \beta \left( \frac{\sigma}{\sigma-\beta} \right) \frac{\partial R(l_I; \varphi)}{\partial l_I} \right].$$

This expression allows us to substitute  $(\partial w_I(l_I, \varphi)/\partial l_I) l_I$  in (7) to obtain

$$w_I(l_I, \varphi) = \left( \frac{\sigma}{\sigma-\beta} \right) \frac{\partial R(l_I; \varphi)}{\partial l_I} - \left( \frac{r+s}{1-\delta} \right) \frac{c}{m(\theta_I)}. \quad (32)$$

Finally, we express the *Wage Curve* as a function of  $\theta_I$  by reinserting (31) into (32)

$$w_I(l_I, \varphi) = rU_I + \left( \frac{\beta}{1-\beta} \right) \left( \frac{r+s}{1-\delta} \right) \frac{c}{m(\theta_I)}. \quad (33)$$

It follows that wages are identical across firms. Thus the workers' outside option reads

$$rU_I(\theta_I) = b + \theta_I m(\theta_I) \left( \frac{w_I - rU_I}{r+s} \right) = b + \frac{\beta}{1-\beta} \left( \frac{c\theta_I}{1-\delta} \right),$$

where (33) is used to drop the dependence of  $w_I$  on  $l_I$  and  $\varphi$ . The Wage curve in Proposition 1 follows after reinserting the expression of  $U_I$  into (33). To simplify the Job Creation curve, consider first a firm

<sup>34</sup>See Bertola and Gariabdi (2001) or Ebell and Haefke (2006) for a detailed solution of a similar ODE by the method of variation of parameters.

that does not export, so that  $I(\varphi) = 0$ . In this case, it is easily seen that the iso-elastic demand (2) implies  $\partial R(l_I; \varphi)/\partial l_I = p_D(l_I; \varphi)\varphi(\sigma - 1)/\sigma$ . This equality also holds true for exporting firms because they are facing the same domestic demand than non-exporting firms and that marginal revenues are equalized across markets. To see this formally, notice that

$$\begin{aligned}\frac{\partial R(l_I; \varphi)}{\partial l_I} &= \left(\frac{\sigma - 1}{\sigma}\right) \left[\frac{Y_I}{M_I^\eta} (1 + n\tau^{1-\sigma})\right]^{1/\sigma} \varphi q(l_I; \varphi)^{-\frac{1}{\sigma}} \\ &= \left(\frac{\sigma - 1}{\sigma}\right) \left(\frac{Y_I}{M_I^\eta}\right)^{1/\sigma} q_D(l_I; \varphi)^{-\frac{1}{\sigma}} \varphi = \left(\frac{\sigma - 1}{\sigma}\right) p_D(l_I; \varphi)\varphi, \text{ when } I(\varphi) = 1.\end{aligned}$$

The second equality holds true because output is optimally allocated across markets when  $q_X = q_D\tau^{1-\sigma}$ . Equation (32) therefore implies that  $p_D(\varphi)\varphi = p_D(\tilde{\varphi})\tilde{\varphi} = M_I^{\frac{1-\eta}{\sigma-1}}\tilde{\varphi}$ , where the last equality follows from the definition of  $\tilde{\varphi}$ . These simplifications lead to the Job Creation condition reported in Proposition 1.

The uniqueness of the equilibrium is ensured since the Wage curve is increasing in  $\theta$  and the Job Creation curve decreasing. For the same reason, a necessary and sufficient condition for existence is that the intercept of the Wage curve be smaller than that of the Job Creation curve, which yields the condition stated in Proposition 1.

**Proof of Proposition 2.** The contract curve is given by the points where the firm iso-profit curves are tangent to the union's indifference curves, so that

$$\frac{\partial \mathbf{F}(l_C, w_C; \varphi)/\partial l_C}{\partial \mathbf{F}(l_C, w_C; \varphi)/\partial w_C} = \frac{\partial \mathbf{U}(l_C, w_C; \varphi)/\partial l_C}{\partial \mathbf{U}(l_C, w_C; \varphi)/\partial w_C} \Rightarrow \frac{\partial R(l_C; \varphi)}{\partial l_C} = rU_C + \left(\frac{r+s}{1-\delta}\right) \frac{c}{m(\theta_C)}. \quad (34)$$

The actual contract solves the following Nash-bargaining problem <sup>35</sup>

$$\max_{w_C, l_C} \Omega(w_C, l_C; \varphi) \equiv \mathbf{U}(l_C, w_C; \varphi)^\beta \mathbf{F}(l_C, w_C; \varphi)^{1-\beta}. \quad (35)$$

The union and the firm split the forward looking surplus.<sup>36</sup> The first order condition with respect to the wage rate is

$$w_C(\varphi, l_C) = (1 - \beta) rU_C + \beta \left[ \frac{R(l_C; \varphi)}{l_C} - \left(\frac{r+s}{1-\delta}\right) \frac{c}{m(\theta_C)} \right] = rU_C + \left(\frac{\beta}{\sigma}\right) \frac{R(l_C; \varphi)}{l_C}, \quad (36)$$

<sup>35</sup>The set-up cost  $F$  is sunk and so cannot be recovered by the firm in case of disagreement with the union. Thus it does not enter the firm outside option. If one assume, as in Melitz (2003), that operating costs are paid in each period, the strategic form of the Nash-bargaining problem still holds as long as the firm cannot default on his payment following a breakdown in the wage negotiation. Notice, however, that when fixed costs are included in the firm threat point, the solution to (35) does not lie on the contract curve and so violates the axiom of Pareto optimality. Hence, our formulation can also be justified on axiomatic ground.

<sup>36</sup>Considering instead that disagreement delays production does not fundamentally affect our result.

where the second equality is obtained substituting the Pareto optimality condition (34) and using the identity  $\partial R(l_C; \varphi)/\partial l_C = (\frac{\sigma-1}{\sigma}) R(l_C; \varphi)/l_C$ . Equation (36) is the *Wage* curve under collective bargaining. The *Job Creation* curve is given by the first order condition of problem (35) with respect to the employment level

$$w_C(\varphi, l_C) = \left(1 - \frac{1-\beta}{\sigma}\right) \frac{R(l_C; \varphi)}{l_C} - \left(\frac{r+s}{1-\delta}\right) \frac{c}{m(\theta_C)}. \quad (37)$$

Both conditions indicate that wages are identical across firms since, as explained in the proof of Proposition 1,  $R(l_C; \varphi)/l_C = p_D(\varphi) \varphi = p_D(\tilde{\varphi}) \tilde{\varphi} = M_C^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}$ . The employees' outside option therefore reads

$$rU_C(\theta_C) = b + \theta_C m(\theta_C) \left(\frac{w_C - rU_C}{r+s}\right) = b + \theta_C m(\theta_C) \left(\frac{\beta}{\sigma(r+s)}\right) M_C^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}, \quad (38)$$

where the last equality follows from (36). Combining the three equations above, yields the expressions in Proposition 2. The existence and uniqueness requirements follow from the same reasoning than in the proof of Proposition 1.

**Proof of Corollary 1.** Combining the Job Creation and Wage curves in Proposition 2 leads to the following equilibrium requirement

$$\Phi(\theta_C; \tilde{\varphi}) \equiv b + \left(\frac{M_C^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}}{\sigma}\right) \left(\beta \left(\frac{\theta_C m(\theta_C) + r+s}{r+s}\right) - \sigma + 1 - \beta\right) + \left(\frac{r+s}{1-\delta}\right) \frac{c}{m(\theta_C)} = 0.$$

Differentiating  $\Phi(\theta_C; \tilde{\varphi})$  with respect to  $\theta_C$  and  $\tilde{\varphi}$  yields

$$\begin{aligned} \frac{\partial \theta_C}{\partial \tilde{\varphi}} &= - \frac{\partial \Phi(\theta_C; \tilde{\varphi})/\partial \tilde{\varphi}}{\partial \Phi(\theta_C; \tilde{\varphi})/\partial \theta_C} = - \frac{\frac{M_C^{\frac{1-\eta}{\sigma-1}}}{\sigma} \left[\beta \frac{\theta_C m(\theta_C) + r+s}{r+s} - \sigma + 1 - \beta\right]}{\frac{M_C^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi} \beta [\theta_C m'(\theta_C) + m(\theta_C)]}{\sigma(r+s)} - \left(\frac{r+s}{1-\delta}\right) \frac{cm'(\theta_C)}{m(\theta_C)^2}} \\ &= \frac{\frac{1}{\tilde{\varphi}} \left[b + \left(\frac{r+s}{1-\delta}\right) \frac{c}{m(\theta_C)}\right]}{\frac{M_C^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi} \beta [\theta_C m'(\theta_C) + m(\theta_C)]}{\sigma(r+s)} - \left(\frac{r+s}{1-\delta}\right) \frac{cm'(\theta_C)}{m(\theta_C)^2}} > 0, \end{aligned}$$

where the last equality follows from  $\Phi(\theta_C; \tilde{\varphi}) = 0$ , and the sign of the inequality holds true due to the homogeneity of degree one of the matching function.

**Proof of Lemma 1.** We first establish that the relationship between  $\varphi_D^*$  and  $\varphi_X^*$  does not depend on  $\theta$ . From the definition of the cutoff productivity we have

$$\pi_X(\varphi_X^*) + f_X - \left(\frac{r+\delta}{1-\delta}\right) \frac{c}{m(\theta)} l_X(\varphi_X^*) = \tau^{1-\sigma} \left[\pi_D(\varphi_X^*) + f - \left(\frac{r+\delta}{1-\delta}\right) \frac{c}{m(\theta)} l_D(\varphi_X^*)\right] = \left(\frac{r+\delta}{1-\delta}\right) f_X.$$

But we also know that employment levels are log-linear functions of  $\varphi$ , so that

$$\begin{aligned}\pi_D(\varphi_X^*) + f - \left(\frac{r+\delta}{1-\delta}\right) \frac{c}{m(\theta)} l_D(\varphi_X^*) &= \left(\frac{\varphi_X^*}{\varphi_D^*}\right)^{\sigma-1} \left[ \pi_D(\varphi_D^*) + f - \left(\frac{r+\delta}{1-\delta}\right) \frac{c}{m(\theta)} l_D(\varphi_D^*) \right] \\ &= \left(\frac{\varphi_X^*}{\varphi_D^*}\right)^{\sigma-1} \left(\frac{r+\delta}{1-\delta}\right) f,\end{aligned}$$

where the last equality follows from the definition of  $\varphi_D$ . Combining the two relations above, yields the same relationship than in Melitz (2003)

$$\varphi_X^* = \tau \varphi_D^* \left(\frac{f_X}{f}\right)^{\frac{1}{\sigma-1}}. \quad (39)$$

This equation allow us to use (19) to pin down  $\varphi_D^*$ . We can then use (14) to express  $\tilde{\varphi}_k$  as a function of  $\varphi_k^*$ , for  $k \in \{D, X\}$ .

**Proof of Proposition 3.** The average levels of employment follow from the requirement that the profits of  $\varphi^*$ -firms be zero

$$l_k(\varphi^*) \left[ \left( M^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi} - w \right) \frac{1-\delta}{r+\delta} - \frac{c}{m(\theta)} \frac{r+s}{r+\delta} \right] = f \left( \frac{1+r}{r+\delta} \right), \text{ for } k \in \{D, X\},$$

and the log-linear relation between firm sizes:  $l_k(\tilde{\varphi}) = (\tilde{\varphi}_k/\varphi_k^*)^{\sigma-1} l_k(\varphi_k^*)$ , for  $k \in \{D; X\}$ . Reinserting the respecting wage curves for both bargaining regimes yields

$$l_k(\tilde{\varphi}_k) = \left(\frac{\tilde{\varphi}_k}{\varphi_k^*}\right)^{\sigma-1} \left(\frac{1+r}{1-\delta}\right) \left(\frac{\sigma-\beta}{1-\beta}\right) \frac{f_k}{M^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}}, \text{ for } k \in \{D, X\},$$

when wages are bargained at the individual level and

$$l_k(\tilde{\varphi}_k) = \left(\frac{\tilde{\varphi}_k}{\varphi_k^*}\right)^{\sigma-1} \left(\frac{1+r}{1-\delta}\right) \left(\frac{\sigma}{1-\beta}\right) \frac{f_k}{M^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}}, \text{ for } k \in \{D, X\},$$

when wages are collectively bargained.

Accordingly, equation (21) in the individual bargaining regime is equivalent to

$$M_{DI} = L \left( \frac{\theta m(\theta_I)}{s + \theta m(\theta_I)} \right) \left( \frac{1-\beta}{\sigma-\beta} \right) \left( \frac{1-\delta}{1+r} \right) \left[ \left( \frac{\tilde{\varphi}_D}{\varphi_D^*} \right)^{\sigma-1} \left( \frac{f}{M_I^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}} \right) + n \varrho \left( \frac{\tilde{\varphi}_X}{\varphi_X^*} \right)^{\sigma-1} \left( \frac{f_X}{M_I^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}} \right) \right]^{-1}$$

where the last equality follows from the Free Entry condition (19).

From equation (19) one knows that

$$n \varrho \left( \frac{\tilde{\varphi}_X}{\varphi_X^*} \right)^{\sigma-1} = \frac{1}{f_X} \left( \left( \frac{r+\delta}{1+r} \right) \frac{f_E}{1-G(\varphi_D^*)} - f \left( \left( \frac{\tilde{\varphi}_D}{\varphi_D^*} \right)^{\sigma-1} - 1 \right) + n \varrho f_X \right) \quad (40)$$

$$= \frac{1}{f_X} \left( \left( \frac{r+\delta}{1+r} \right) \frac{f_E}{1-G(\varphi_D^*)} - f \left( \frac{\tilde{\varphi}_D}{\varphi_D^*} \right)^{\sigma-1} + f + n \varrho f_X \right) \quad (41)$$

which gives rise to

$$M_{DI} = M_I^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi} L \left( \frac{\theta_I m(\theta_I)}{s + \theta_I m(\theta_I)} \right) \left( \frac{1-\beta}{\sigma-\beta} \right) \left( \frac{1-\delta}{1+r} \right) \left[ \left( \frac{r+\delta}{1+r} \right) \frac{f_E}{1-G(\varphi_D^*)} + f + n\varrho f_X \right]^{-1},$$

In order to get the final solution for the number of available varieties, one has to take  $M_I = (1+n\varrho)M_D$  into consideration. After solving for  $M_I$  one gets

$$\begin{aligned} M_I &= M_{DI}(1+n\varrho) \\ &= M_I^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi} \left( (1+n\varrho)L \left( \frac{\theta_I m(\theta_I)}{s + \theta_I m(\theta_I)} \right) \left( \frac{1-\beta}{\sigma-\beta} \right) \left( \frac{1-\delta}{r+s} \right) \left( \left( \frac{r+\delta}{1+r} \right) \frac{f_E}{1-G(\varphi_D^*)} + f + n\varrho f_X \right)^{-1} \right) \\ &= \left( (1+n\varrho)L \left( \frac{\theta_I m(\theta_I)}{s + \theta_I m(\theta_I)} \right) \left( \frac{1-\beta}{\sigma-\beta} \right) \left( \frac{1-\delta}{r+s} \right) \tilde{\varphi} \left( \left( \frac{r+\delta}{1+r} \right) \frac{f_E}{1-G(\varphi_D^*)} + f + n\varrho f_X \right)^{-1} \right)^{\frac{1-\sigma}{2-\sigma-\eta}}. \end{aligned}$$

#### *Collective bargaining*

Accordingly, the equilibrium masses of active firms in the home market still depends on the total mass of varieties available and is given by

$$M_{DC} = L \left( \frac{\theta_C m(\theta_C)}{s + \theta_C m(\theta_C)} \right) \left( \frac{1-\beta}{\sigma} \right) \left( \frac{1-\delta}{r+s} \right) \left( \left( \frac{\varphi_D^*}{\tilde{\varphi}} \right)^{\sigma-1} \left( \frac{M_C^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}}{f} \right) + \frac{1}{\varrho} \left( \frac{\varphi_X^*}{\tilde{\varphi}_X} \right)^{\sigma-1} \left( \frac{M_C^{\frac{1-\eta}{\sigma-1}} \tilde{\varphi}}{f_X} \right) \right)$$

for the collective bargaining setup. The the total mass of varieties available in the home market becomes

$$\begin{aligned} M_C &= M_{DC}(1+n\varrho) \\ &= \left( (1+n\varrho)L \left( \frac{\theta_C m(\theta_C)}{s + \theta_C m(\theta_C)} \right) \left( \frac{1-\beta}{\sigma} \right) \left( \frac{1-\delta}{r+s} \right) \tilde{\varphi} \left[ \left( \left( \frac{r+\delta}{1+r} \right) \frac{f_E}{1-G(\varphi_D^*)} + f + n\varrho f_X \right)^{-1} \right] \right)^{\frac{1-\sigma}{2-\sigma-\eta}}. \end{aligned}$$

**Proof of Proposition 4.** From Melitz (2003) we know, that trade liberalization due to lower variable trade costs or an increasing number of trade liberalization leads to an increase in the average productivity of intermediate inputs producers for the case of  $\eta = 1$ . Hence, we do not further proof the following

$$\frac{\partial \tilde{\varphi}}{\partial \tau} < 0 \quad \frac{\partial \tilde{\varphi}}{\partial n} > 0$$

which hold for both bargaining regimes. In addition the following proofs show, what happens to the equilibrium market tightness and the wage rate in case of an increasing aggregate average productivity.

*The individual bargaining regime.* Combining the Job Creation and Wage curves from the individual bargaining setup leads to the following equilibrium requirement

$$\Phi(\theta_I; \tilde{\varphi}) \equiv b - \tilde{\varphi}_I \left( \frac{\sigma-1}{\sigma-\beta} \right) + \frac{1}{1-\beta} \left( \frac{c}{m(\theta_I)} \left( \frac{r+s}{1-\delta} \right) \right) + \frac{\beta}{1-\beta} \frac{c\theta_I}{1-\delta}$$

Differentiating  $\Phi(\theta_I; \tilde{\varphi})$  with respect to  $\theta_I$  and  $\tilde{\varphi}$  yields

$$\frac{\partial \theta_I}{\partial \tilde{\varphi}} = - \frac{\partial \Phi(\theta_I; \tilde{\varphi}) / \partial \tilde{\varphi}}{\partial \Phi(\theta_I; \tilde{\varphi}) / \partial \theta_I} = - \frac{- \left( \frac{\sigma-1}{\sigma-\beta} \right)}{- \frac{1}{1-\beta} \frac{cm'(\theta_I)}{m(\theta_I)^2} \left( \frac{r+s}{1-\delta} \right) + \frac{\beta}{1-\beta} \frac{c}{1-\delta}} > 0$$

which is positive due to  $m'(\theta_I) < 0$ . Additionally, the first differential of the Wage Curve with respect to  $\theta$

$$\frac{\partial w_I}{\partial \theta_I} = - \frac{1}{1-\beta} \frac{cm'(\theta_I)}{m(\theta_I)^2} \left( \frac{r+s}{1-\delta} \right) + \frac{\beta}{1-\beta} \frac{c}{1-\delta}$$

which proves that wages in the individual bargaining regime are increasing in market tightness.

*The collective bargaining regime.* We have already shown in the proof Proposition 2 that  $\theta$  is increasing in  $\tilde{\varphi}$  in the collective bargaining regime. To show that this is also the case for wages, we totally differentiate the Wage Curve

$$\frac{dw_C}{d\theta_C} = \frac{d\tilde{\varphi}}{d\theta_C} \frac{\beta}{\sigma} \left( \frac{\theta_C m(\theta_C) + r + s}{r + s} \right) + \tilde{\varphi} \frac{\beta}{\sigma} \left( \frac{m(\theta_C) + \theta_C m'(\theta_C)}{m(\theta_C)^2} \frac{1}{r + s} \right) > 0$$

Thus, in the collective bargaining regime wages are also increasing in market tightness.

## C Technical Appendix

### C.1 Derivation of the Average Productivity Under Free Trade

The average price level in the open economy is given by

$$P = \left\{ M_t^{-\eta} \left[ M \int_{\varphi^*}^{\infty} \left( \frac{\varphi}{\tilde{\varphi}_t} \right)^{\sigma-1} \frac{g(\varphi)d\varphi}{1-G(\varphi^*)} + M_x n \tau^{1-\sigma} \int_{\varphi_x^*}^{\infty} \left( \frac{\varphi}{\tilde{\varphi}_t} \right)^{\sigma-1} \frac{g(\varphi)d\varphi}{1-G(\varphi_x^*)} \right] \right\}^{\frac{1}{1-\sigma}} .$$

Since  $p(\varphi) = p(\tilde{\varphi}_t)(\tilde{\varphi}_t/\varphi)$ , we have

$$P = \left\{ M_t^{-\eta} p(\tilde{\varphi}_t)^{1-\sigma} \left[ M \int_{\varphi^*}^{\infty} \left( \frac{\varphi}{\tilde{\varphi}_t} \right)^{\sigma-1} \frac{g(\varphi)d\varphi}{1-G(\varphi^*)} + M_x n \tau^{1-\sigma} \int_{\varphi_x^*}^{\infty} \left( \frac{\varphi}{\tilde{\varphi}_t} \right)^{\sigma-1} \frac{g(\varphi)d\varphi}{1-G(\varphi_x^*)} \right] \right\}^{\frac{1}{1-\sigma}} .$$

Using the normalization of the aggregated price level to 1,  $M_x = \varrho M$  and  $M_t = (1 + n\varrho)M$  as well as

$$\tilde{\varphi}^{\sigma-1} = \left[ \int_{\varphi^*}^{\infty} \varphi^{\sigma-1} \frac{g(\varphi)d\varphi}{1-G(\varphi^*)} \right] \quad \tilde{\varphi}_x^{\sigma-1} = \left[ \int_{\varphi_x^*}^{\infty} \varphi^{\sigma-1} \frac{g(\varphi)d\varphi}{1-G(\varphi_x^*)} \right] ,$$

we obtain

$$1 = M_t^{1-\eta} \frac{p(\tilde{\varphi}_t)^{1-\sigma}}{1+n\varrho} \left[ \left( \frac{\tilde{\varphi}}{\tilde{\varphi}_t} \right)^{\sigma-1} + n\varrho \tau^{1-\sigma} \left( \frac{\tilde{\varphi}_x}{\tilde{\varphi}_t} \right)^{\sigma-1} \right] .$$

We define the aggregate productivity as in Melitz (2003)

$$\tilde{\varphi}_t = \left[ \frac{1}{1+n\varrho} [\tilde{\varphi}^{\sigma-1} + n\varrho \tau^{1-\sigma} \tilde{\varphi}_x^{\sigma-1}] \right]^{\frac{1}{\sigma-1}} .$$

Reinserting this definition in the previous equation implies that the price level of the representative firm is given by

$$p(\tilde{\varphi}_t) = M_t^{\frac{1-\eta}{\sigma-1}} . \quad (42)$$

Obviously, the aggregate average productivity condition remains the same, with and without external scale effects.



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