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International trade and unemployment: The worker-selection effect

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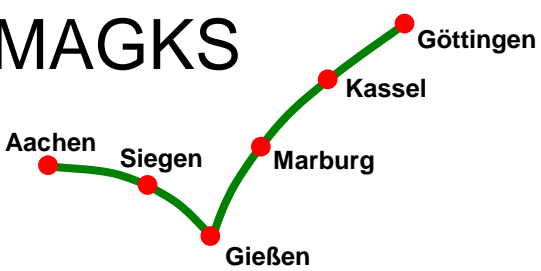
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International Trade and Unemployment - the Worker-Selection Effect*

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Abstract

This paper analyzes how trade liberalization influences the unemployment rate of workers with different abilities. We refine the Melitz (2003) framework to account for trade unions and heterogeneous workers, who differ with respect to their abilities. Our main findings are: (i) high-ability workers profit from trade liberalization in terms of higher wages and higher employment; (ii) the least efficient workers loose their job and switch to long-term unemployment (worker-selection effect); (iii) if a country is endowed with a large fraction of low-skilled workers, trade liberalization leads to a rise in aggregate unemployment. In this case, trade liberalization may harm a country's welfare.

JEL-Classification: F1, F16, J5

Keywords: trade liberalization, trade unions, skill-specific unemployment

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1 Introduction

The impact of trade liberalization on a country's labor market situation is a core issue in modern trade theory. For a world with homogeneous firms, homogeneous workers and perfect competition on product and labor markets the mechanisms are well-known. However, for a world with heterogeneous firms, heterogeneous workers and imperfect competition, wage and employment effects are context-specific. Most prominent in the recent debate is *Melitz* (2003). He focuses on heterogeneous firms with varying productivities and shows that trade liberalization reallocates workers into high productivity firms, generating a rise in the real wage. But *Melitz* (2003) sticks to the assumption of perfect labor markets and disregards the issue of unemployment. The gap was filled by the incorporation of search and matching frictions (*Felbermayr et al.*, 2008; *Helpman and Itskhoki*, 2010), efficiency wages (*Egger and Kreickemeier*, 2009; *Davis and Harrigan*, 2011), and unionized labor markets (*Eckel and Egger* 2009). These studies show that trade liberalization is good for the real wage. For (un-)employment, however, the results are mixed.

A common shortcoming of these models is the assumption of homogeneous workers. As a result, the models' outcomes are not in line with the by now well-established empirical finding that the employment (and wage) effect of trade liberalization is skill-specific, namely that low- and high-skilled workers are affected differently. Take, for instance, *Wood* (1995), *Bazen and Cardebat* (2005), and *Biscourp and Kramarz* (2007), who all conclude that trade openness increases the unemployment rate of low-skilled workers. By contrast, the analyses of *Bernard and Jensen* (1997), *Feenstra and Hanson* (2003), and *Verhoogen* (2008) indicate that trade liberalization implies an increasing demand for high-skilled workers.

The contribution of this paper is to extend the *Melitz*-framework by allowing for worker heterogeneity, namely that workers differ with respect to their abilities. In our model, trade liberalization leads to a worker-selection effect: all firms demand higher worker abilities, and since the least efficient workers do not meet this increase in the quality requirement, they lose their jobs and become (long-term) unemployed. High-ability workers profit from trade liberalization via an increase in both wages and employment. For aggregate (un-)employment and welfare the net effect depends on the parameter constellation. In particular, if a country is endowed with a large fraction of low-skilled workers, trade liberalization leads to a rise in aggregate unemployment. In this case, trade liberalization may harm a country's welfare.

Clearly, the analysis of the relationship between trade liberalization and skill-specific unemployment is not totally new. In particular, *Larch and Lechthaler* (2011) and *Helpman et al.* (2010a, b) discuss this issue within the *Melitz*-framework. The work by *Helpman et al.* (2010a, b) is the one most closely related to our analysis. In accordance with these authors we assume that workers are heterogeneous with respect to their abilities, abilities are Pareto distributed. The production technology depends on entrepreneurial productivity, drawn from the *Melitz*-lottery, the number of workers and the average ability of

the employees. Each firm chooses an ability cut-off, workers with abilities below this threshold are not hired.

However, two shortcomings of the *Helpman et al.*-approach are noteworthy. First, worker ability is assumed to be match-specific and independently distributed. Hence, a worker's ability draw for a given match does not convey any information about his or her ability for other (future) matches. The ability of an individual worker is unobservable, even if the worker has an "employment history". Second, workers accept all job offers, the wage does not matter. Since workers do not know their abilities, they do not compare a wage offer with a reservation wage, thus, they do not solve any optimization problem concerning the job search. Solely the firm decides on the formation of a match. Low-productive and thus low-wage firms may thus employ high-skilled workers. This scenario is counterintuitive and it is in contrast to the empirical observation that individuals are only disposed to work for a firm if the wage is sufficiently high (see *Dunne et al.* 2004; *Caselli*, 1999; *Kremer and Maskin*, 1996). In our model, workers know their abilities, each worker chooses a reservation wage, and each refuses wage offers below this level. As a result, we obtain a firm-specific interval of abilities. Firms with high entrepreneurial productivity demand workers with high abilities, they pay high wages and thus attract high-ability workers. Firms with low entrepreneurial productivity have a low minimum quality requirement, they pay low wages and thus do not recruit high-ability workers.

In addition to the incorporation of heterogeneous workers, we assume a unionized labor market, wages are bargained at the firm level and employment is set by firms (right-to-manage privilege). Since the members of a union differ with respect to their abilities, they differ with respect to the rent of unionization. We follow *Booth* (1984) and assume that the union's objective is to maximize the expected utility of the median member. As a result, the wage bargain leads to the well-known Nash solution: the wage rate is a constant markup on the median member's fallback income. Owing to the correlation between worker abilities and the fallback income, high-productivity firms have to pay higher wages than do low-productivity firms, which is well in line with the empirical observations (see *Munch and Skaksen*, 2008; *Bayard and Troske*, 1999). The question of how a unionized labor market affects the labor market outcome has also been tackled by *Eckel and Egger* (2009). But these authors have a different focus, they address the incentives of multinational firms to invest abroad in order to improve their positions in the bargain with local unions.

To compute the general equilibrium we make use of the well-known concepts of wage-setting and price-setting schedules (see *Layard et al.*, 1991). The key assumption driving our results at the aggregate level is the specification of the outside wage, i.e., the wage that the median member of a trade union can expect in the economy. The outside wage is assumed to be a convex combination of the median member's ability (microeconomic variable) and the aggregate wage level (macroeconomic variable). This approach accounts for the fact that high-skilled workers expect higher wage rates than do low-skilled workers.

We find three main results. First, the demand for high-skilled workers increases because of trade liberalization. A reduction in variable trade costs initi-

ates an intensification of firm selection and improves the average entrepreneurial productivity in the economy. Hence, the feasible real wage increases and firms raise their labor demand. Trade unions boost their target real wage, too. But the net effect remains positive – the unemployment rate falls.

Second, sharper firm-selection drives out the least productive firms and – as a consequence of the firm-specific interval of abilities – the least efficient workers as well. Some low-skilled workers can no longer meet the minimum quality requirement of all active firms and switch to a (long-term) unemployment status. Clearly, the reduction in the demand for low-skilled workers increases the unemployment rate. We call this the worker-selection effect.

Third, the (net) effect of trade liberalization on the aggregate unemployment rate is ambiguous. If a country is endowed with a large number of low-skilled workers and/or firms demand a high minimum ability and/or the weight of the microeconomic variable of the outside wage is low, then the destruction of low-skilled workplaces dominates the increasing labor demand. In this case trade liberalization may even harm a country's welfare.

Our model does not allow for technology upgrading. *Yeaple* (2005) and *Bas* (2009) develop a set-up where firms discover their productivities in the *Melitz*-lottery, but in addition they have the opportunity to upgrade their technologies. These studies show that notably exporters with high productivities use the technology upgrade and therefore increase their demand for high-skilled workers. We suppose that the incorporation of this channel would reinforce our results.

The structure of the paper is as follows. In section two, we present the set-up of the model at the sectoral level, while the general equilibrium will be derived in section three. In section four, we discuss the macroeconomic effects of a switch from autarky to trade and of trade liberalization. Section five concludes.

2 Model

2.1 Set-up

Our model builds on the standard monopolistic competition model with heterogeneous firms by *Melitz* (2003). The economy consists of two sectors, a final good sector produces a homogeneous good Y under perfect competition, and a monopolistic competitive sector with M firms produces a continuum of differentiated intermediate goods (see *Egger* and *Kreickemeier*, 2009).

The production technology of the final goods producer is assumed to be a CES aggregate of all the available intermediate goods (see *Blanchard* and *Giavazzi* 2003):

$$Y = M^{\frac{1}{1-\sigma}} \left[\int_{\nu \in V} q(\nu)^{\frac{\sigma-1}{\sigma}} d\nu \right]^{\frac{\sigma}{\sigma-1}} ; \quad P = M^{\frac{1}{\sigma-1}} \left[\int_{\nu \in V} p(\nu)^{1-\sigma} d\nu \right]^{\frac{1}{1-\sigma}},$$

where P is the corresponding price index. V denotes the mass of all potentially available goods M , and σ represents the elasticity of substitution between

varieties ($\sigma > 1$).¹ We suppose Y to be the numéraire, which allows the normalization of the price index: $P \equiv 1$. The demand for variety v can be derived from the profit maximization of the final goods producers:

$$q(\nu) = \frac{Y}{M} (p(\nu))^{-\sigma}. \quad (1)$$

In the intermediate goods sector there is a continuum of ex-ante homogeneous firms. Following *Melitz* (2003), firms enter the differentiated sector by paying a fixed entry cost $f_e > 0$ (measured in units of final goods). They observe their productivity ϕ , which is drawn from a Pareto distribution $G_\phi(\phi) = 1 - (\phi_{\min}/\phi)^k$ for $\phi \geq \phi_{\min} = 1$ and $k > 1$. The lower bound of productivities is normalized to one. Our interpretation of the parameter ϕ is slightly different to that of *Melitz* (2003). We prefer the term entrepreneurial (instead of firm) productivity in order to distinguish between the quality of the management and originality of the business idea, and a firm's total productivity, which also depends on the quality of the employed workers. For an empirical study consistent with this interpretation, see *Wagner* (2010).

The economy is endowed with an exogenous number of heterogeneous workers \bar{L} , who differ in their abilities a_j , $j = 1, \dots, \bar{L}$. In accordance with *Helpman et al.* (2010a, b), worker abilities are drawn from a Pareto distribution $G_a(a) = 1 - (a_{\min}/a)^k$ for $a \geq a_{\min} = 1$. In contrast to *Helpman et al.* (2010a, b), however, abilities are not match-specific and independently distributed, but individuals are assumed to know and maintain their ability levels at any point in time.

Consider a firm i with productivity ϕ_i . The production technology is given by:

$$q_i = h_i \phi_i \bar{a}_i, \quad (2)$$

where h_i and \bar{a}_i represent the number of employees and the average ability of employees, respectively. Note that the marginal product of labor arises from the interaction between management quality and the workers' abilities.

A firm does not demand all abilities but sets a minimum quality requirement. The minimum quality requirement is firm-specific, and it increases with the entrepreneurial productivity ϕ . For concreteness, we assume (see *Albrecht and Vroman*, 2002; and *Helpman et al.*, 2010a, b, for similar approaches):

$$a_i^* = \phi_i^\alpha \quad \text{with} \quad \alpha \geq 0. \quad (3)$$

Eq. (3) represents a firm's technology constraint: firm i does not employ workers with abilities lower than a_i^* because their marginal product of labor is zero (or even negative because of complementarities, see *Helpman et al.* (2010a, b)). The parameter α denotes the sensitivity of a_i^* with respect to the entrepreneurial productivity. Assumption (3) is motivated by the empirical studies of *Dunne et*

¹The technology rules out a "love of variety"-index. This closes down the familiar channel, in which trade increases welfare because of external scale effects (see *Melitz* 2003, *Krugman* 1980) and allows us to find new insights concerning the trade-welfare relationship.

al. (2004), *Caselli* (1999), and *Kremer and Maskin* (1996), who all show that firms with a high management quality do not employ workers with low abilities. *Kremer and Maskin* (1996) illustrate this result with the evolution of economic activities. They argue that economic activity has shifted from firms such as General Motors, which use both high- and low-skilled workers, to firms such as Microsoft and McDonald's, whose workers are much more homogeneous. To put it differently, the low-productive firm McDonald's primarily demands workers with low qualification, e.g. collectors, while the high-productive firm Microsoft primarily employs high-skilled workers, e.g. computer scientists.

The wage offer matters. Just as a firm might not want to hire a low-ability worker, a worker may not want to work for a low-wage firm. Individuals differ with respect to their reservation wage w^* . The higher the ability of an individual, the higher is the marginal product of labor, the higher is the reservation wage. As a result, a firm that tends to employ a specific worker has to offer him or her a wage rate at least as high as his or her reservation wage.

Hence, we can identify an upper bound of abilities for each firm. If firm i offers a wage rate w_i , there will be a worker that is indifferent between (short-term) unemployment and employment in firm i . We define this worker as employee z with ability $a_z = a_i^z$ and reservation wage w_z^* . The indifference condition is given by:

$$w_i = w_z^*. \quad (4)$$

For $w_i = w_z^*$ firm i attracts workers with abilities $a \leq a_i^z$, workers with $a > a_i^z$ do not accept the wage offer as it is below their reservation wage. Note that a firm is able to influence the upper bound of employees' abilities by offering a higher wage: $\partial a_i^z / \partial w_i > 0$.

As a result, the abilities of firm i 's employees lie within the interval a_i^* and a_i^z , where the interval depends on the productivity ϕ_i and wage rate w_i . As shown in Appendix A, we can calculate the average ability of the firm-specific interval as:

$$\bar{a}_i = \Gamma_1 \frac{(a_i^*)^{1-k} - (a_i^z)^{1-k}}{(a_i^*)^{-k} - (a_i^z)^{-k}} \quad \text{with} \quad \Gamma_1 \equiv \frac{k-1}{k}, \quad (5)$$

where $\partial \bar{a}_i / \partial a_i^z > 0$. A wage increase swells the average abilities and thus total labor productivity. In order to ensure stability we follow *Akerlof and Yellen* (1986) and assume that the elasticity of the average ability with respect to wages is lower than one:

$$\epsilon_{\bar{a},w} \equiv \frac{\partial \bar{a}}{\partial w} \frac{w}{\bar{a}} < 1 \quad \forall i. \quad (6)$$

The determination of employment and wages at the sectoral level is modelled as a five-stage game, which we solve by backward induction. In the first stage, firm i participates in the *Melitz* lottery and discovers its entrepreneurial productivity ϕ_i . Given ϕ_i , firm i decides whether to produce or not. In the case of production, firm i posts a vacancy (stage two). The job description includes the minimum quality requirement a_i^* and a wage offer w_i , where we insinuate

that firms anticipate correctly the outcome of the wage bargain in stage four. Therefore, the offered wage will be identical to the paid wage w_i . Additionally, posting a vacancy is assumed to be costless. More precisely, the advertisement does not create variable costs.

In the third stage, workers that conform to the requirements (3) and (4) apply for the job. To extract an economic rent, the applicants form a trade union at the firm level. Consequently, all members n_i of union i have abilities that lie within the interval a_i^* and a_i^z .

The fourth stage consists of the wage bargain between firm i and union i ; both parties anticipate the employment decision of the firm in stage five. After the firm has set the optimal employment level h_i , it draws randomly workers from the union members until h_i is reached. Since all union members fulfil the minimum quality requirement and all the union members accept the wage offer w_i , there will be a “drawing without repetition”. Note that we abstract from a (costly) screening technology. Firms are assumed to observe the minimum ability of a worker at no costs, but they are not able to observe the exact value of a of an individual worker. Furthermore, note that the existence of unions eliminates any wage differentiation within firms.

2.2 Labor demand

We begin by discussing stage five, where w_i , a_i^z , a_i^* , and \bar{a}_i are already determined. Profits of firm i are defined by $\pi_i = r_i - w_i h_i - f$, where r_i is real revenue and f is the fixed input requirement of each intermediate good (measured in units of final goods). f can be interpreted as beachhead costs, which also include the (fixed) costs of vacancy posting. Each firm faces a constant elasticity demand curve (1). Thus, the firm’s revenue $r_i = q_i p_i$ is given by

$$r_i = q_i^\kappa M^{-1/\sigma} Y^{1/\sigma}, \quad \kappa \equiv 1 - \frac{1}{\sigma}, \quad (7)$$

where κ denotes the degree of competitiveness in the market for intermediate goods. The firm maximizes profits by setting employment such that the marginal revenue of labor equals marginal costs: $\partial r_i / \partial h_i = w_i$. The optimal level of employment is given by

$$h_i = \left(\frac{\kappa \phi_i^\kappa \bar{a}_i^\kappa}{w_i} \right)^\sigma \frac{Y}{M} \quad (8)$$

with $\partial h_i / \partial w_i < 0$. Note that the number of firms M and the aggregate output Y are exogenous at the sectoral level. The optimal price

$$p_i = \frac{1}{\kappa} \frac{w_i}{\phi_i \bar{a}_i} \quad (9)$$

is a constant markup $1/\kappa$ over marginal costs.

2.3 Wage bargaining and fallback income

In the fourth stage, firm i and trade union i bargain over the wage rate w_i , at which the number of union members n_i is already fixed. As shown above, union members are heterogeneous with respect to their abilities, which lie within the interval a_i^* and a_i^z . Following *Booth* (1984), we assume that the union maximizes the expected utility of the median member m_i . The union objective function is given by:

$$EU_i^m = \frac{h_i}{n_i} w_i + \left(1 - \frac{h_i}{n_i}\right) b_i^m \quad (10)$$

with b_i^m denoting the fallback income of the median member. By assumption, the membership n_i exceeds the firm's labor demand h_i and the unions are risk neutral.

In the wage bargaining, w_i is chosen to maximize the Nash product

$$NP_i = \left(EU_i^m - \bar{U}_i^m\right)^\gamma (\pi_i - \bar{\pi}_i)^{1-\gamma}$$

with γ ($0 \leq \gamma \leq 1$) being the union's bargaining power. If the bargaining fails, employment and production fall back to zero. Consequently, the threat points of the union and the firm are given by $\bar{U}_i^m = b_i^m$ and $\bar{\pi}_i = -f$, respectively. Substituting (10), the firm's profit $\pi_i = r_i - h_i w_i - f$ and the threat points in the Nash product implies $NP_i = (h_i/n_i (w_i - b_i))^{\gamma} (r_i - h_i w_i)^{1-\gamma}$. The solution of the optimization problem leads to a well-known result: the wage w_i is a markup θ over the median member's fallback income b_i^m :

$$w_i = \theta b_i^m \quad \text{with} \quad \theta \equiv \frac{\gamma - \kappa(1 - \gamma)(1 - \epsilon_{\bar{a}, w})}{\gamma\kappa - \kappa(1 - \gamma)(1 - \epsilon_{\bar{a}, w})} \geq 1. \quad (11)$$

The union generates an economic surplus for its members, which we define as the difference between the wage rate w_i and the fallback income of the median member b_i^m . The wage markup θ does not vary with the entrepreneurial productivity ϕ_i . Low-productivity firms face the same mark-up as do high-productivity firms. This result is in line with the empirical finding of *Bratsberg* and *Ragan* (2002), who analyze the evolution of union wage markups for 32 US-industries over the period 1971-1999. They observe a convergence process for the union wage markups since the late 1980s. Using UK data, *Blanchflower* and *Bryson* (2004) confirm this result.

We complete the analysis of stage four by the derivation of the fallback income b_i^m (see *Layard* and *Nickell*, 1990). The median member m_i can be either unemployed or employed. The value functions are:

$$\begin{aligned} V_{m_i} &= \frac{1}{1 + \rho} [\bar{w}_{m_i} + (1 - \delta) V_{m_i} + \delta V_{m_i}^u] \\ V_{m_i}^u &= \frac{1}{1 + \rho} [z_{m_i} V_{m_i} + (1 - z_{m_i}) V_{m_i}^u], \end{aligned}$$

where ρ represents the discount factor and δ denotes the probability of the firm's death (exogenous and independent of productivity). Therefore, δ can also

be interpreted as the probability of job loss for any employee. The likelihood that a worker will switch from unemployment to a job is captured by z_{m_i} . For analytical simplicity, we normalize the marginal utility of leisure and the unemployment benefits to zero.

Let us turn to the outside wage \bar{w}_{m_i} , which is defined as the median member's expected wage rate in the economy. The empirical literature shows that wages are determined by both individual characteristics and a country's macroeconomic performance (see, for instance, *Fairris and Jonasson, 2008; Nickell and Kong, 1992; Holmlund and Zetterberg, 1991*). We take up this observation by assuming that the outside wage is a convex combination of a microeconomic and a macroeconomic variable:

$$\bar{w}_{m_i} = (a_i^m)^\omega \left(w(\tilde{\phi}) \right)^{1-\omega} \quad 0 < \omega \leq 1. \quad (12)$$

The microeconomic variable is the ability a_i^m of union i 's median member. The outside wage is increasing in a_i^m , i.e., high-skilled workers expect a higher wage compared with low-skilled workers. The macroeconomic variable is the wage rate which holds in the general equilibrium, $w(\tilde{\phi})$, where $\tilde{\phi}$ denotes the entrepreneurial productivity of the representative firm (see below). Note that $w(\tilde{\phi})$ is exogenous at the sectoral level.

In a steady state, the flow equilibrium for any qualification level must hold. The flow equilibrium for, e.g., the ability a_i^m requires the inflow from employment to unemployment to be equal to the outflow from unemployment to employment:

$$\delta (1 - u_{m_i}) = z_{m_i} u_{m_i}. \quad (13)$$

Entrepreneurial productivity and workers' abilities are both Pareto distributed with identical lower bounds and shape parameter k . These characteristics imply that the ratio of employed workers with ability j , H_j to the number of all workers with ability j , L_j is equal for all j . As a result, the unemployment rate is identical across all abilities:

$$u = u_j = 1 - \frac{H_j}{L_j} \quad \forall j. \quad (14)$$

Following *Layard and Nickell (1990)*, we define the fallback income as the period income of an unemployed worker: $b_i^m \equiv \rho V_{m_i}^u$. From the value functions, (12), (13) and (14), we obtain:

$$b_i^m = (1 - u) (a_i^m)^\omega \left(w(\tilde{\phi}) \right)^{1-\omega}. \quad (15)$$

The bargained wage (11) can thus be rewritten as:

$$w_i = \theta (1 - u) (a_i^m)^\omega \left(w(\tilde{\phi}) \right)^{1-\omega}, \quad (16)$$

where the unemployment rate u is exogenous at the sectoral level. Note that the fallback income b_i^m corresponds to the reservation wage of the median member: $b_i^m = w_{m_i}^*$

Owing to heterogeneous individuals, the economic surplus $(w_i - b_i)$ differs between union members. Within the firm's and the union's ability interval, the worker with the minimum qualification, i.e. a_i^* , obtains the largest rent (lowest fallback income). According to (16), the surplus declines with members' ability levels, because of an increasing fallback income. Member z with the highest qualification has a zero surplus, which makes him or her indifferent between taking a job in firm i and looking for a job elsewhere.

2.4 Unions, vacancy posting and Melitz lottery

Stage three determines union membership n_i . At this point, a_i^* and the wage offer w_i are already given; hence, two bounds exist for the potential members. The lower bound is given by $a = a_i^*$, the upper bound being $w_i = w_z^*$, which we can rewrite as $w_i = b_i^z$. Inserting (15) and rearrangements leads to:

$$a_i^z = w_i^{1/\omega} (1 - u)^{-1/\omega} \left(w(\tilde{\phi}) \right)^{(\omega-1)/\omega}. \quad (17)$$

Following *Booth* (1984), the number of union members is thus given by:

$$n_i = \int_{a_i^*}^{a_i^z} k a^{-(1+k)} da = (a_i^*)^{-k} - (a_i^z)^{-k}.$$

The posting of the vacancy is the topic of stage two, where a firm's entrepreneurial productivity ϕ_i is predetermined. Firm i announces the minimum quality requirement (3) and a wage offer. Since firm i anticipates the bargaining outcome correctly, the wage offer is given by (16). The wage offer implicitly determines the highest quality a_i^z and thus the average ability \bar{a}_i . Substituting the wage rate (16) into (17) leads to $a_i^z = \theta^{1/\omega} a_i^m$. As shown in Appendix A, the ability of the median member can be derived as:

$$a_i^m = 2^{1/k} \left[(a_i^z)^{-k} + (a_i^*)^{-k} \right]^{-1/k}. \quad (18)$$

Inserting this result into $a_i^z = \theta^{1/\omega} a_i^m$ and noting $a_i^* = \phi_i^\alpha$, we obtain:

$$a_i^z = \left(2\theta^{k/\omega} - 1 \right)^{1/k} \phi_i^\alpha. \quad (19)$$

If a firm knows its entrepreneurial productivity ϕ_i , it sets a minimum ability according to (3) and the ability of the efficient worker is given by (19). Note that the ability of the efficient worker and thus the average ability is increasing in the union's bargaining power (higher wage markup θ).

From (3), (11), (15), (18), and (19) we obtain:

$$w_i = \theta b_i^m = \left(2\theta^{k/\omega} - 1 \right)^{\omega/k} (1 - u) \left(w(\tilde{\phi}) \right)^{1-\omega} \phi_i^{\alpha\omega}. \quad (20)$$

The wage rate w_i is increasing in the entrepreneurial productivity ϕ_i . High-productivity firms have to pay higher wages than do low-productivity firms, since the ability and thus the fallback income of the median member of the corresponding trade union is higher. The empirical literature supports this result (see, for instance, *Munch and Skaksen, 2008; Bayard and Troske, 1999*).

In stage one, firm i participates in the *Melitz*-lottery and draws the entrepreneurial productivity ϕ_i . Subsequently, it has to decide whether to enter the market and to produce or not. A firm will produce if and only if the expected stream of profits is non-negative. Two conditions must hold in the case of production, the free entry condition and the zero cut-off profit condition (see *Melitz, 2003*). We follow *Egger and Kreickemeier (2009)* and derive from these conditions the cut-off productivity level:

$$\phi^* = \left(\frac{f\beta}{(k-\beta)f_e\delta} \right)^{1/k} \quad (21)$$

with $\beta \equiv (\sigma - 1)(1 + \alpha - \alpha\omega) > 0$ and ϕ^* representing the lowest productivity, which is compatible with a non-negative expected profit stream of a firm. For $\phi_i < \phi^*$, the firm will not enter the market. Note that changes in the union bargaining power γ have no impact on the cut-off productivity ϕ^* . For a similar result, see *Eckel and Egger (2009)*.

The existence of such a marginal firm with productivity ϕ^* has important consequences for the segregation of the labor force of the economy. Analogous to firm i , the marginal firm also sets a minimum quality requirement a^* . Since no firm has a lower entrepreneurial productivity, a^* can be interpreted as the minimum quality requirement for the whole economy. For workers with $a < a^*$, their abilities are not sufficient to gain any job, as no active firm on the market will demand qualifications below a^* . With (3), we obtain:

$$a^* = (\phi^*)^\alpha. \quad (22)$$

Thus, we divide the labor force \bar{L} into two groups: (i) active² workers L with $a \geq a^*$ and $u = 1 - H/L < 1$ and (ii) (long-term) unemployed persons L^l with $a < a^*$ and $u^l = 1$. The latter will never be members of a union because they are not able to meet the job requirements. Consequently, unions and firms only account for active workers in the bargaining process.

3 General equilibrium

So far, we have described the model at the sectoral level. To gain insights into the labor market effects of both trade unions and trade liberalization in the presence of trade unions, we now derive the general equilibrium.

² "Active" means that these workers have a positive employment probability. Nevertheless, at each point in time a fraction of "active" workers is unemployed.

3.1 Average productivity and aggregation

Consider the weighted average productivity level $\tilde{\phi}$ first. By following the step-by-step derivation of *Egger and Kreckemeier (2009)*, we get:

$$\tilde{\phi} = \left[\frac{k}{k - \beta} \right]^{1/\beta} \phi^*, \quad k > \beta. \quad (23)$$

Product market clearing requires the profit-maximizing price to be $p(\tilde{\phi}) = 1$. With this at hand we calculate the aggregate variables as $Y = Mq(\tilde{\phi})$, $R = Mr(\tilde{\phi})$ and $\Pi = M\pi(\tilde{\phi})$. For aggregate employment H , we obtain:

$$H = Mh(\tilde{\phi})\xi_1\xi_2; \quad \text{with} \quad \xi_1 \equiv \left[\frac{k}{k - \beta} \right]^{\alpha\omega/\beta}, \quad \xi_2 \equiv \frac{k - \beta}{k - \beta + \alpha\omega}. \quad (24)$$

As mentioned above, we distinguish between the unemployment rate of low-skilled workers u^l and the unemployment rate of active workers u . The aggregate (total) unemployment rate \bar{u} is a weighted average of u^l and u . By using the probabilities $P(a < a^*) = 1 - (a^*)^{-k}$ and $P(a > a^*) = (a^*)^{-k}$ as weights, we yield $\bar{u} = u^l \frac{L^l}{L} + u \frac{L}{L} = 1 \cdot (1 - (a^*)^{-k}) + u \cdot (a^*)^{-k} = 1 - (1 - u)(a^*)^{-k}$. Noting that $u = 1 - H/L$, the aggregate unemployment rate simplifies to

$$\bar{u} = 1 - (a^*)^{-k} \frac{H}{L}. \quad (25)$$

The higher the minimum quality requirement, the higher is the share of unemployed low-skilled workers and the higher is the aggregate unemployment rate.

The aggregate variables have an important property (see *Melitz, 2003*): the aggregate levels of P , Y , R , Π , and H are identical to what they would be if the economy were endowed with M identical firms with productivity $\tilde{\phi}$. Therefore, we treat the firm with productivity $\tilde{\phi}$ as the representative firm of the economy.

3.2 Equilibrium unemployment, welfare and wage distribution

In order to pin down the aggregate unemployment rate in the general equilibrium, we make use of the well-known concepts of wage-setting and price-setting schedules (see *Layard et al., 1991*). Consider first aggregate price-setting behavior. The representative firm chooses $p(\tilde{\phi}) = 1$. Then, the price rule (9) delivers the feasible real wage:

$$w_{PS}(\tilde{\phi}) = \kappa \bar{a}(\tilde{\phi}, \theta) \cdot \tilde{\phi}. \quad (26)$$

The feasible real wage is independent of (un-)employment, which is no surprise because of our assumptions on technology (output is linear in labor) and the constant price elasticity of product demand. However, the feasible real wage is positively affected by trade unions. More powerful trade unions increase the

wage markup θ , which in turn increases the ability of the efficient worker [see (19)], and thus the average ability \bar{a} [see (5)], and thus the feasible real wage.

Let us turn to the target real wage. The representative firm bargains with the representative union over the wage rate. The result is given by (20). Taking the macroeconomic variables as given, the target real wage of the representative union can be written as

$$w_{WS}(\tilde{\phi}) = \left(2\theta^{k/\omega} - 1\right)^{\omega/k} \cdot \left(w(\tilde{\phi})\right)^{1-\omega} (1-u) \cdot \tilde{\phi}^{\alpha\omega}. \quad (27)$$

The higher the bargaining power of the union, the higher the outside wage and the lower the unemployment rate of active workers, the higher is the target real wage.

In the general equilibrium, we have $w_{PS}(\tilde{\phi}) = w_{WS}(\tilde{\phi}) = w(\tilde{\phi})$. By combining (26) and (27), we can compute the unemployment rate of the active workers as (see Appendix B):

$$u = 1 - \Gamma_3 \cdot \tilde{\phi}^{\omega}, \quad (28)$$

where Γ_3 is a positive constant defined in Appendix B. Note that the unemployment of active workers is decreasing in the average productivity $\tilde{\phi}$ and independent of the labor force \bar{L} .

In a next step, we derive the number of long-term unemployed, L^l . Inserting (22) and (23) into $L^l = (1 - (a^*)^{-k})\bar{L}$ produces

$$L^l = \left(1 - \xi_3 \cdot \tilde{\phi}^{-\alpha k}\right) \bar{L} \quad \text{with} \quad \xi_3 \equiv \left(\frac{k}{k - \beta}\right)^{\alpha k/\beta}. \quad (29)$$

An increase in the cut-off productivity ϕ^* , which translates into an increase in the average productivity $\tilde{\phi}$, leads to a rise in workers' minimum quality requirement, see (22). The least efficient workers are driven out of the market and switch to long-term unemployment. This is the worker-selection effect. If the economy is endowed with a large proportion of low-skilled workers and a large proportion of low entrepreneurial productivities (high k), the worker-selection effect will be strong. Similarly, the more sensitive the minimum quality requirement responses to a change in ϕ^* (high α), the stronger is the worker-selection effect.

The number of active workers is straightforward to derive:

$$L = \bar{L} - L^l = \xi_3 \cdot \tilde{\phi}^{-\alpha k} \cdot \bar{L}. \quad (30)$$

The number of employed active workers $H = (1 - u)L$ is given by

$$H = \xi_3 \Gamma_3 \cdot \tilde{\phi}^{\omega - \alpha k} \cdot \bar{L}. \quad (31)$$

The employment effect of higher entrepreneurial productivity is ambiguous. We identify three channels through which a higher ϕ affects employment: the feasible real wage, the target real wage and the worker-selection effect. However, we postpone the discussion of these effects to section 4.2.

The aggregate unemployment rate \bar{u} turns out to be

$$\bar{u} = 1 - \xi_3 \Gamma_3 \cdot \tilde{\phi}^{\omega - \alpha k}. \quad (32)$$

Next, we derive the level of welfare. We choose per capita output Y/\bar{L} as the measure of welfare. As pointed out by *Melitz* (2003), aggregate profits are used to finance the initial investments f_e of firms. Thus, only the wage income is available for consumption. Due to the markup pricing rule, the per capita wage income is then equal to a constant share κ of per capita output: $W/\bar{L} = \kappa Y/\bar{L}$. Using the technology assumption (2) and (24), the per capita output is $Y/\bar{L} = Mq(\tilde{\phi})/\bar{L} = Mh(\tilde{\phi})\bar{a}(\tilde{\phi}, \theta)\tilde{\phi}/\bar{L} = H\bar{a}(\tilde{\phi}, \theta)\tilde{\phi}/(\xi_1 \xi_2 \bar{L})$. Now insert (31) and (B2) (see Appendix B) to arrive at

$$\frac{Y}{\bar{L}} = \frac{\Gamma_1 \Gamma_2 \Gamma_3 \xi_3}{\xi_1 \xi_2} \cdot \tilde{\phi}^{1 + \alpha + \omega - \alpha k}. \quad (33)$$

Finally, we consider the distribution of wages in the general equilibrium. Following *Egger* and *Kreickemeier* (2009), we choose the ratio of the average wage rate, \bar{w} , to the lowest wage rate, $w(\phi^*)$, as measure of wage inequality. The average wage rate is defined by $\bar{w} \equiv W/H = \kappa Y/H$. Observing $Y = Mq(\tilde{\phi})$, (2), (24), and (26) yields $\bar{w} = w(\tilde{\phi})/\xi_1 \xi_2$. By combining (20) with (23) the lowest wage can be computed as $w(\phi^*) = w(\tilde{\phi})/\xi_1$. Consequently, our measure of wage inequality is given by:

$$\frac{\bar{w}}{w(\phi^*)} = \frac{1}{\xi_2} = \frac{k - \beta + \alpha \omega}{k - \beta}. \quad (34)$$

If the minimum quality requirement does not depend on the entrepreneurial productivity but is identical across all firms ($\alpha = 0$), we are back in the *Melitz*-world of all firms paying the same wage. There would be no wage inequality. The same holds true, if the ability of the union's median member does not matter for his or her fallback income ($\omega = 0$).

We are now in a position to discuss the impact of an increase in the unions' bargaining power on the labor market variables and welfare. By virtue of (21) and (23), ϕ^* and $\tilde{\phi}$ remaining constant, there is no shift in the minimum quality requirement, no worker-selection effect, and no change in the segregation of the labor force into active workers and long-term unemployed. Thus, L and L^l are not affected. However, the wage markup θ goes up, that is, unions boost the target real wage at any given level of employment. Firms respond to such an increase in their marginal costs with a rise in the profit-maximizing price. Product and labor demand drop, and the unemployment rate of active workers rises. Moreover, the increase in the wage markup θ implies a widening of the interval of abilities. The lower bound remains constant, but the wage hike attracts workers with higher abilities. For any firm the ability of the efficient worker goes up, and so does average ability, the feasible real wage and employment. Concerning employment, the former effect always dominates the latter effect, so aggregate employment declines. Concerning output and welfare the decline in

employment and the increase in labor productivity work in opposite directions, and so the sign of the net effect depends on the sign of $\epsilon_{\bar{a},w}(1+\omega) - \frac{A+1}{A}$. The results are summarized in:

Proposition 1 *Suppose that there is an increase in union bargaining power. Then, (i) the segregation of the labor force into active workers and long-term unemployed is not affected; (ii) the real wage increases, (iii) the employment of active workers declines, and (iv) wage inequality remains constant. (v) For $\epsilon_{\bar{a},w}(1+\omega) > \frac{A+1}{A}$ output and welfare increase, but for $\epsilon_{\bar{a},w}(1+\omega) < \frac{A+1}{A}$ output and welfare decrease.*

Proof. see text and Appendix C. ■

We complete our model by computing the number of firms in the same way as in *Egger and Kreickemeier (2009)*, which yields:

$$M = \frac{Y}{\xi_4} \quad \text{with} \quad \xi_4 \equiv \frac{fk\sigma}{k - \beta}.$$

4 Open economy

4.1 Modifications

We now turn to an open economy setting with two symmetric countries.³ Two types of trade costs are distinguished: (i) fixed per period costs $f_x \geq 0$, measured in units of final output, and (ii) variable iceberg costs $\tau > 1$. If the partitioning assumption $f_x \tau^{\sigma-1} > f$ holds, only a fraction of firms engages in exporting. In the open economy setting, M now denotes the number of firms located in each country. Let M_x be the number of exporters in each country. Then, the total number of all active firms and thus the number of all available varieties in a country is $M_t = M + M_x$.

The export variables can be expressed as a function of the domestic variables (see *Melitz, 2003*): $p_{ix} = \tau p_i$, $q_{ix} = \tau^{-\sigma} q_i$, $h_{ix} = \tau^{1-\sigma} h_i$ and $r_{ix} = \tau^{1-\sigma} r_i$. The profit-maximizing price as well as the output, employment, revenue and profit of exporters are determined by the equations in section 2. The decision to export or not depends on the entrepreneurial productivity. Firms will export if and only if the profits from exporting are non-negative: $\pi_x \geq 0$. There is a critical export productivity cut-off, defined by $\pi_x(\phi_x^*) = 0$, where a firm just breaks even in the export market. For $\phi \geq \phi_x^*$, firms are exporters and produce for both the home and foreign markets. For $\phi^* \leq \phi < \phi_x^*$, firms produce for the home market only. The ex ante probability of being an exporter is given by

$$\chi = \frac{1 - G_\phi(\phi_x^*)}{1 - G_\phi(\phi^*)} = \left(\frac{\phi^*}{\phi_x^*} \right)^k.$$

³We abstract from differences in country size, technologies etc. See *Pflüger and Russek (2010)* for a treatment of these asymmetries.

With these modifications at hand we are able to compute the weighted average productivity of all active firms in a country, $\tilde{\phi}_t$. In line with *Egger* and *Kreickemeier* (2009), we obtain:

$$\tilde{\phi}_t = \tilde{\phi} \left[\frac{1}{1 + \chi} \left(1 + \chi \tau^{1-\sigma} \left(\frac{\tilde{\phi}_x}{\tilde{\phi}} \right)^\beta \right) \right]^{1/\beta}, \quad (35)$$

where $\tilde{\phi}$ is the average productivity of all domestic firms and $\tilde{\phi}_x$ is the average productivity of exporting firms. Owing to the Pareto distribution, these productivities are given by:

$$\tilde{\phi}_x = \left[\frac{k}{k - \beta} \right]^{1/\beta} \phi_x^* \quad (36)$$

$$\tilde{\phi} = \left[\frac{k}{k - \beta} \right]^{1/\beta} \phi^*. \quad (37)$$

To simplify the analysis we assume that the per period domestic fixed costs f are equal to the per period foreign fixed costs f_x . In this case, the “lost in transit” and the “export selection” effects exactly offset each other, the average productivity of domestic firms, $\tilde{\phi}$, is equal to the average productivity of all firms active in a country, $\tilde{\phi}_t$ (see *Egger* and *Kreickemeier*, 2009). Formally, we use $f_x = f$, the zero profit conditions, (36), and (37) to obtain:

$$\left(\frac{\phi_x^*}{\phi^*} \right)^\beta = \left(\frac{\tilde{\phi}_x}{\tilde{\phi}} \right)^\beta = \tau^{\sigma-1}. \quad (38)$$

Substituting (38) into (35) leads to $\tilde{\phi}_t = \tilde{\phi}$. Furthermore, (38) implies $\chi = \tau^{-k/(1+\alpha-\alpha\omega)}$, namely that the probability of being an exporter is decreasing in the iceberg costs.

The aggregate variables, which again can be interpreted as product market clearing conditions, are derived in the standard way with the underlying assumption of an equalized balance of payments. It follows: $P = p(\tilde{\phi}_t) \equiv 1$, $Y = M_t q(\tilde{\phi}_t)$, $R = M_t r(\tilde{\phi}_t)$ and $\Pi = M_t \pi(\tilde{\phi}_t)$. Moreover, note that $M_t = M(1 + \chi)$. For the employment level, we get:

$$H = h(\tilde{\phi}_t) \xi_1 \xi_2 \psi_1, \quad (39)$$

where $\psi_1 \equiv M + M_x (\phi^*/\phi_x^*)^{\alpha\omega} = M + M_x \tau^{-\alpha\omega/(1+\alpha-\alpha\omega)}$. For a given level of $\tilde{\phi}_t$, aggregate employment is increasing in the number of firms and decreasing in the iceberg costs. In particular, the employment of exporters is a negative function of τ .

We complete our model by the derivation of the general equilibrium in the open economy. In doing so, we calculate the feasible real wage and the target real wage in analogy to the autarky case and obtain:

$$w_{PS}(\tilde{\phi}_t) = \kappa \bar{a}(\tilde{\phi}_t) \cdot \tilde{\phi}_t \quad (40)$$

$$w_{WS}(\tilde{\phi}_t) = \left(2\theta^{k/\omega} - 1\right)^{\omega/k} \cdot \left(w(\tilde{\phi}_t)\right)^{1-\omega} (1-u) \cdot \tilde{\phi}_t^{\alpha\omega} \quad (41)$$

The unemployment rate of active workers u , the number of active workers L , the number of employed active workers H , the number of long-term unemployed L^l , and the aggregate unemployment rate of the labor force \bar{u} can be computed as:

$$u = 1 - \Gamma_3 \cdot \tilde{\phi}_t^\omega \quad (42)$$

$$L = \xi_3 \cdot \tilde{\phi}_t^{-\alpha k} \cdot \bar{L} \quad (43)$$

$$H = \Gamma_3 \cdot \tilde{\phi}_t^{1-(1-\omega)-\alpha k} \cdot \bar{L} \quad (44)$$

$$L^l = \left(1 - \xi_3 \cdot \tilde{\phi}_t^{-\alpha k}\right) \bar{L} \quad (45)$$

$$\bar{u} = 1 - \xi_3 \Gamma_3 \cdot \tilde{\phi}_t^{\omega-\alpha k}. \quad (46)$$

Welfare is then given by $Y/\bar{L} = M_t q(\tilde{\phi}_t)/\bar{L} = M_t h(\tilde{\phi}_t) \bar{a}(\tilde{\phi}_t, \theta) \tilde{\phi}_t/\bar{L} = M_t \frac{\bar{a}(\tilde{\phi}_t, \theta) \tilde{\phi}_t}{\xi_1 \xi_2 \psi_1} \frac{H}{\bar{L}}$.

Observing the definition of ψ_1 as well as (44) and $\bar{a} = \Gamma_1 \Gamma_2 \tilde{\phi}^\alpha$ from (B2) in Appendix B, we get:

$$\frac{Y}{\bar{L}} = \psi_2 \cdot \frac{\Gamma_1 \Gamma_2 \Gamma_3 \xi_3}{\xi_1 \xi_2} \cdot \tilde{\phi}_t^{1+\alpha+\omega-\alpha k} \quad (47)$$

with

$$\psi_2 \equiv \frac{1 + \chi}{1 + \chi^{(\alpha\omega+k)/k}} > 1. \quad (48)$$

The measure for wage inequality is derived in the same way as in the autarky case. It follows:

$$\frac{\bar{w}}{w(\phi^*)} = \psi_2 \cdot \frac{k - \beta + \alpha\omega}{k - \beta}. \quad (49)$$

Finally, we calculate the cut-off productivity level and obtain:

$$\phi^* = \left[\frac{f\beta(1+\chi)}{(k-\beta)f_e\delta} \right]^{1/k}. \quad (50)$$

4.2 Autarky versus trade – macroeconomic implications

The transition from autarky to trade causes the well-known firm-selection effect (see *Melitz*, 2003), which occurs because of an increase in the cut-off productivity ϕ^* . The market opening increases the number of available product varieties, which implies a reduction in the demand for any individual firm. The degree of competitiveness in the home market increases, and the least productive firms exit. Firms that produce solely for the domestic market incur a profit decline because of the reduction in demand. Exporters gain from the foreign market, but only the most productive firms make up for their loss of domestic sales and the per period fixed costs f_x , and increase their profits. Observing (21), (23), (37), (50), and $\tilde{\phi}_t = \tilde{\phi}$, we conclude that there is an increasing average productivity of all active firms:

$$\frac{\tilde{\phi}_t}{\tilde{\phi}_a} = \frac{\phi^*}{\phi_a^*} = (1 + \chi)^{1/k} > 1, \quad (51)$$

where the index a denotes the autarky situation.

We now turn to the implications of trade openness for the labor market to shed some light on the unemployment-trade relationship. Namely, our focus will be on the impact of trade on the (un-)employment of low-skilled and high-skilled workers.

Let us start with the segregation of workers into long-term unemployed and active workers. By comparing (29) with (45) and (30) with (43), we observe a shift towards long-term unemployment, i.e. the number of long-term unemployed L^l unambiguously increases, whereas the number of active workers L unambiguously decreases. The increase in the cut-off productivity leads to a rise in workers' minimum quality requirement, and thus the least efficient workers are driven out of the market and switch to long-term unemployment (worker-selection effect). As mentioned above, the higher k and/or α , the stronger is the worker-selection effect.

The worker-selection effect also reduces employment H (see Eq.(43)). But there are two additional effects. The increase in average productivity $\tilde{\phi}_t$ reduces the marginal costs of the representative firm, shifting up the feasible real wage and labor demand. The employment of active workers increases one-to-one. This effect, however, is mitigated by an increase in the target real wage. According to (3), the representative firm increases its minimum quality requirement, while the union focuses on a median member with higher abilities than before and bargains for a higher wage. The increase in the target real wage will be reinforced by the improvement in macroeconomic performance. The outside wage of the median member increases (see (12)), and due to a higher fallback income the union enhances its wage claim. If the weight of the macroeconomic component of the outside wage is large (low ω , high $1 - \omega$), unions respond to the increase in the feasible real wage with a nearly proportional increase in the target real wage. For $\omega = 0$, the combined effect on the feasible and the target real wage cancels out with respect to employment. The overall employment

effect of higher entrepreneurial productivity collapses to the worker-selection effect, see (44). For $0 < \omega < \alpha k$, the rise in the feasible real wage is larger than the rise in the target real wage, but the positive impact on employment does not compensate for the worker-selection effect. The net-effect of trade openness on employment is negative. A necessary (and sufficient) condition for a positive overall employment effect of trade openness is $\omega > \alpha k$.

Concerning the unemployment rate of active workers, $u = 1 - H/L$, the result is clear-cut: u declines, see (42). The pool of workers that fulfill the minimum ability requirement diminishes (lower L). Depending on the parameter constellation, there may be a decline in employment H , too, but the decline in H is always lower than is the decline in L . Consequently, the unemployment rate u unambiguously decreases.

A decline in the unemployment rate of active workers is not equivalent to a decline in the rate of aggregate unemployment \bar{u} . The reason is clear: due to the worker-selection effect, some active workers switch to long-term unemployment (u declines but \bar{u} rises). As indicated by (46), the condition for the change in \bar{u} is identical to the condition for the change in H . Since, by assumption, only active workers can be employed, an increase in H must go hand in hand with a decline in \bar{u} , vice versa. To be more precise, for $\omega > \alpha k$ employment H rises (\bar{u} declines), whereas for $\omega < \alpha k$ employment declines (\bar{u} rises). We summarize all these results in:

Proposition 2 *Suppose that an economy switches from autarky to trade. Then, higher average entrepreneurial productivity $\tilde{\phi}_t$ leads to (i) a higher number of long-term unemployed, (ii) a lower number of active workers, and (iii) a decline in the unemployment rate of active workers. (iv) For $\omega < \alpha k$, the negative worker-selection effect exceeds the rise in the feasible real wage, aggregate employment of active workers declines, and the rate of aggregate unemployment goes up. (v) For $\omega > \alpha k$, the positive impact of a higher feasible wage outweighs the worker-selection effect, thus, the aggregate employment of active workers increases and the rate of aggregate unemployment goes down.*

Proof. see text ■

Next, we consider the trade-welfare relationship, where welfare is proxied by per capita output. Welfare is affected through different channels that may work in opposite directions. The sign of the net effect is parameter-dependent.

These channels are the increase in active workers, the worker-selection effect, the rise in both entrepreneurial productivity and workers' average abilities, and, finally, the composition effect of the surviving firms.

Proposition 3 *(i) The condition $\psi_2(1 + \chi)^{(1+\alpha+\omega-\alpha k)/k} > 1$ is necessary and sufficient for a positive welfare effect of trade openness. (ii) For a mild worker-selection effect, $\alpha k < 1 + \alpha + \omega$, the welfare effect is unambiguously positive; and (iii) for a strong worker-selection effect, $\alpha k > 1 + \alpha + \omega$, welfare may even decline.*

Proof. Noting $\tilde{\phi}_t/\tilde{\phi}_a = (1 + \chi)^{1/k} > 1$ from (51), the ratio of welfare in the open-economy setting (47) and welfare in autarky (33) is greater than unity, if

and only if $\psi_2(1 + \chi)^{(1+\alpha+\omega-\alpha k)/k} > 1$ holds. Since we have $\psi_2 > 1$ (see (48)), the condition is fulfilled for $\alpha k < 1 + \alpha + \omega$. For $\alpha k > 1 + \alpha + \omega$, the term $(1 + \chi)^{(1+\alpha+\omega-\alpha k)/k}$ is lower than unity, which is necessary but not sufficient for a negative welfare effect of trade openness. ■

If the worker-selection effect is weak, trade openness has a positive impact on aggregate employment and thus on output and welfare. Only if trade openness reduces aggregate employment, $\alpha k > \omega$, does the welfare effect becomes more complex. Owing to the technology assumption (2), the increase in entrepreneurial productivity directly raises output one to one. In addition, the switch of the least efficient workers to long-term unemployment causes an increase in the average abilities of the active workers. This raises output by the factor α . If these two positive effects on output exceed the negative employment effect, $1 + \alpha > \alpha k - \omega$, welfare improves (part (ii) of Proposition 4). The welfare effect of trade openness turns negative, if the worker-selection effect compensates for both the output effects just described and the composition effect of the surviving firms. Only the more productive firms survive under openness; the most productive firms are able to export and become even bigger, which increases output per capita and welfare. This effect is captured in $\psi_2 > 1$.

In the last step, we turn to the effects on wage distribution. From (34) and (49), it follows that the wage differential $\bar{w}/w(\phi^*)$ widens. The rise in the average wage rate exceeds the rise in the wage paid by the least productive active firm. This result coincides with Egger and Kreickemeier (2009).

5 Trade liberalization

In order to model the impact of economic integration, the switch from autarky to trade is a popular but polar case. A different modeling approach is the assumption of a decline in iceberg costs, that is, a decline in trade barriers between countries, that already trade with each other. These scenarios are similar, but not identical. In this section we will point out that, in particular, the welfare effect of trade liberalization and the impact on wage distribution may differ.

Let us start with the labor market. We know from (38) that the probability of being an exporter is decreasing in the iceberg costs, $\chi = \tau^{-k/(1+\alpha-\alpha\omega)}$. A lower τ leads to a larger fraction of exporters. Moreover, due to a higher degree of competition, the domestic cut-off productivity ϕ^* increases, see (50). This translates into an increase in the average productivities $\tilde{\phi}$ and $\tilde{\phi}_t$. For the employment effects, we thus get the same results as in the case of a switch from autarky to trade.

Proposition 4 *The employment effects of a decline in iceberg costs are equivalent to the employment effects of a switch from autarky to trade. Specifically, (i) for a weak worker-selection effect, $\alpha k < \omega$, aggregate employment improves, and (ii) for a strong worker-selection effect, $\alpha k > \omega$, aggregate employment declines.*

Proof. See Proposition 3 and note that $\partial\phi^*/\partial\tau < 0$. ■

The theoretical results are in line with the empirical literature. First, there is strong evidence for the increasing demand for high-skilled workers due to trade liberalization. Take, for instance, *Verhoogen* (2008), who shows for the Mexican manufacturing sector that only the most productive firms became exporters by producing high-quality commodities. These firms demand more high-skilled workers that conform to these high technology requirements. Similarly, for the US industry *Bernard and Jensen* (1997) find that exporters boost their high-skilled labor demand. Second, there is much empirical evidence for a positive correlation between trade openness and the unemployment of low-skilled workers. *Biscourp and Kramarz* (2007) use the French Customs files to show that increasing imports lead to job destruction, in particular production jobs. Moreover, job destruction is significantly higher for larger firms. *Bazen and Cardebat* (2001) find that the decline in import prices in France between 1985 and 1992 caused a reduction in low-skilled employment. Finally, *Wood* (1995) finds empirical support for the hypothesis that the deteriorating situation of low-skilled workers in developed countries can be tracked back to trade with developing countries. Third, to the best of our knowledge, there is no clear empirical evidence for the sign of the relationship between trade and the aggregate unemployment rate. *Trefler* (2004) analyses the effects of the North American Free Trade Agreement. He finds evidence for the firm-selection effect, which increases productivity, but lowers employment. This is in contrast to, for instance, *Dutt et al.* (2009) and *Felbermayr et al.* (2009), who find that trade either reduces unemployment or has no effect on it.

We now turn to the welfare effects of trade liberalization. Differentiating output per capita (47) with respect to iceberg costs, we have:

$$\text{sign} \left(\frac{\partial(Y/\bar{L})}{\partial\tau} \right) = \text{sign} \left[\psi_2(1 + \alpha + \omega - \alpha k) \frac{\partial\tilde{\phi}_t}{\partial\tau} + \tilde{\phi}_t \frac{\partial\psi_2}{\partial\tau} \right]. \quad (52)$$

The first summand in the square brackets replicates the trade openness scenario. A reduction in iceberg costs increases the cut-off and average productivity, ϕ^* and $\tilde{\phi}_t$, respectively. Noting $\partial\tilde{\phi}_t/\partial\tau < 0$, the first summand is negative if the worker-selection effect is weak, that is, if $1 + \alpha + \omega - \alpha k > 0$. Then, trade liberalization enhances welfare. For a strong worker-selection effect, $1 + \alpha + \omega - \alpha k < 0$, the first summand turns into positive and welfare declines, *ceteris paribus* (see Proposition 3).

But in the case of trade liberalization we observe an additional effect, reflected in the second summand in the square brackets of (52). The composition of firms changes by virtue of ψ_2 . On the one hand, the export cut-off falls and consequently more firms engage in the foreign market, which increases their profits – and welfare shifts up (higher ψ_2). On the other hand, the productivity cut-off increases, which forces the least productive firms out of the market and welfare decreases (lower ψ_2). Formally, we can use $\chi = \tau^{k/(\alpha(\omega-1)-1)}$ and (38) to identify a critical $\bar{\tau} > 1$ (see *Egger and Kreickemeier* 2009):

$$\text{sign}\left(\frac{\partial\psi_2}{\partial\tau}\right) = \text{sign}\left[\alpha\omega - \frac{k\left(\tau^{\frac{\alpha\omega}{1+\alpha-\alpha\omega}} - 1\right)}{1 + \tau^{\frac{-k}{1+\alpha-\alpha\omega}}}\right]. \quad (53)$$

We get $\partial\psi_2/\partial\tau < 0$ if $\tau < \bar{\tau}$, and $\partial\psi_2/\partial\tau > 0$ if $\tau > \bar{\tau}$. The following proposition summarizes the welfare effect:

Proposition 5 (i) *If the worker-selection effect is weak and iceberg costs are low, $1 + \alpha + \omega - \alpha k > 0$ and $\tau < \bar{\tau}$, trade liberalization increases welfare.* (ii) *If the worker-selection effect is strong and iceberg costs are high, $1 + \alpha + \omega - \alpha k < 0$ and $\tau > \bar{\tau}$, trade liberalization lowers welfare.* (iii) *In all other cases the welfare effect is ambiguous.*

Finally, we use (49) to analyze the effect of trade liberalization on wage distribution. A reduction of τ implies a decrease in the export productivity cut-off, shifting up the number of exporting firms that pay relatively higher wages. Wage inequality thus increases (higher ψ_2). But trade liberalization also implies a higher degree of competitiveness; the cut-off productivity and the lowest wage rate increase. Ceteris paribus, wage inequality decreases (lower ψ_2). Combining these effects, we find (see *Egger and Kreickemeier, 2009*, for a similar result):

Proposition 6 (i) *If iceberg costs are low, $\tau < \bar{\tau}$, trade liberalization increases wage inequality, whereas, (ii) if iceberg costs are high, $\tau > \bar{\tau}$, trade liberalization reduces wage inequality.*

The predictions of our model concerning employment and welfare very much depend on the parameters ω , α and k . What are the most plausible parameter values? The strength of the worker-selection effect is most sensitive to the shape parameter k of the Pareto distribution. Conducting a general equilibrium simulation of trade policy, *Balistreri et al. (2011)* estimate a value of $k = 5.2$, but the authors immediately admit that this number seems to be somewhat high. The calibration exercise of *Bernard et al. (2007)* assumes $k = 3.4$, the estimates in *Eaton et al. (2004)* imply $k = 4.2$, while *Corcos et al. (2009)* find a value of k close to 2. The parameter ω , measuring the weight of the abilities in the wage determination, has been estimated only in a few studies. *Keane (1993)* claims that 84 percent of wage differences across industries are explained by individual fixed effects, while only 16 percent can be traced back to industry dummies. The strong weight of individual characteristics in the wage determination is confirmed by, for instance, *Fairris and Jonasson (2008)* and *Holmlund and Zetterberg (1991)*. Hence, a value of $\omega = 0.8$ does not seem at odds with the empirical literature. Unfortunately, to the best of our knowledge, there is no empirical estimation for the parameter α , which captures the strength of the minimum quality requirements. Intuitively, α should be close to but smaller than 1. Given these parameter specifications, the case $\omega < \alpha k$ is most likely. Our model thus predicts an increase in aggregate unemployment. The welfare effect is more difficult to sign, since even for the most plausible parameter values $1 + \alpha + \omega$ may exceed or fall short of αk . Note, however, that

our model does not allow for a love of variety effect and thus underestimates the welfare effect.

6 Conclusion

This paper investigates the labor market effects of trade liberalization. We incorporate trade unions and heterogeneous workers into the *Melitz* (2003) framework. Workers differ with respect to their abilities. It is shown that the employment effect of trade liberalization is ability-specific. The central mechanism underlying our results is the worker-selection effect, which in turn is based on the assumption that firms with a high entrepreneurial productivity demand workers with a high (minimum) ability. Since trade liberalization raises the cut-off entrepreneurial productivity, trade liberalization also leads to a rise in workers' minimum quality requirement and thus the least efficient workers are driven out of the market and switch to long-term unemployment. For workers with abilities lower than the increased minimum requirement employment decreases (to zero). By contrast, for workers with high abilities employment increases. The change in aggregate employment is ambiguous. If a country is endowed with a large fraction of low-skilled workers, trade liberalization leads to a decline in aggregate employment. In this case, trade liberalization may even harm a country's welfare.

Last but not least let us mention some limitations of our framework. Most crucial, from our point of view, is the assumption that the shape parameter of the Pareto-distribution of the entrepreneurial productivities is identical to the shape parameter of the Pareto-distribution of workers' abilities. It is most plausible that different shape parameters would modify the conditions for the sign of the employment and welfare effect. We leave this problem for further research. A more fundamental criticism is concerned with the lack of a flow equilibrium between (long-term) unemployment and employment. Once a worker falls short of the minimum ability requirement, he or she switches to long-term unemployment and there is no opportunity to switch back into employment. There are two ways out of this problem, either assume a search-theoretic labor market or endogenize the decision to invest in human capital in order to explain the distribution of worker abilities. For such an approach, see *Meckl and Weigert* (2011).

7 Appendix

Appendix A

Derivation of the average ability (5):

We modify the density function $g_a(a)$ because of $a^* > a_{\min}$ and obtain the density function and the corresponding distribution function for all active

workers:

$$\mu_a(a) = \frac{g_a(a)}{1 - G_a(a^*)} = \frac{k}{a} \left(\frac{a^*}{a} \right)^k \quad \Omega_a(a) = 1 - \left(\frac{a^*}{a} \right)^k.$$

However, firm i demands only abilities that lie within the interval a_i^* and a_i^z . Thus, the modification of $\mu_a(a)$ leads to the density function of firm i 's ability interval:

$$\zeta(a) = \frac{\mu_a(a)}{\Omega_a(a_i^z) - \Omega_a(a_i^*)} = \frac{ka^{-k-1}}{(a_i^*)^{-k} - (a_i^z)^{-k}} \quad \text{for} \quad a_i^* \leq a \leq a_i^z. \quad (\text{A1})$$

Next, we compute the expected value of (A1), which immediately leads to

$$\bar{a}_i = \Gamma_1 \frac{(a_i^*)^{1-k} - (a_i^z)^{1-k}}{(a_i^*)^{-k} - (a_i^z)^{-k}} \quad \text{with} \quad \Gamma_1 \equiv \frac{k-1}{k}. \quad (\text{A2})$$

Equation (A2) corresponds to (5) in the text.

Derivation of the ability of the median member (18):

To obtain the median of the ability interval (a_i^*, a_i^z) , we first calculate the corresponding distribution function of (A1):

$$Z(a) = \int_{a_i^*}^{a_i^z} \zeta(a) da = \frac{a^{-k} - (a_i^*)^{-k}}{(a_i^z)^{-k} - (a_i^*)^{-k}}.$$

Next, we convert $Z(a)$ into the quantile function, which equals the inverse of $Z(a) = p_q$. The median a_i^m is defined as the 0.5 quantile, $a_i^m = Z^{-1}(0.5)$, which leads to Eq. (18) in the text: $a_i^m = 2^{1/k} \left[(a_i^z)^{-k} + (a_i^*)^{-k} \right]^{-1/k}$.

Appendix B

Derivation of the unemployment rate of the active workers (28):

Combine (26) and (27) to eliminate the wage. This leads to

$$\kappa \bar{a} \tilde{\phi} = A^{1/k} (1-u)^{1/\omega} \cdot \tilde{\phi}^\alpha \quad \text{with} \quad A \equiv 2\theta^{k/\omega} - 1 > 1. \quad (\text{B1})$$

Inserting the minimum quality requirement (3), the upper bound of abilities (19) and $\phi_i = \tilde{\phi}$ into the average ability (A2) yields :

$$\bar{a} = \Gamma_1 \Gamma_2(\theta) \cdot \tilde{\phi}^\alpha \quad \text{with} \quad \Gamma_2(\theta) \equiv \frac{A - A^{1/k}}{A - 1}. \quad (\text{B2})$$

Substitute (B2) into (B1) and rearrange for the unemployment rate of active workers:

$$u = 1 - \Gamma_3(\theta) \cdot \tilde{\phi}^\omega \quad \text{with} \quad \Gamma_3(\theta) \equiv \left(\frac{\kappa \Gamma_1 \Gamma_2}{A^{1/k}} \right)^\omega.$$

Appendix C:

Proof of part (iii) of Proposition 1

We compute the relation between unions' bargaining power and the employment level of active workers. Remember that an increase in γ raises the wage-markup θ and shifts up the wage rate, which in turn increases the average ability (B2). The stability of the equilibrium requires the assumption $\epsilon_{\bar{a},w} = \frac{\partial \bar{a}}{\partial w} \frac{w}{\bar{a}} = \frac{\partial \Gamma_2}{\partial \theta} \frac{\theta}{\Gamma_2} < 1$. From (31) follows $\text{sign} \frac{\partial H}{\partial \gamma} = \text{sign} \frac{\partial \Gamma_3}{\partial \gamma}$. Given the parameter definitions we get:

$$\begin{aligned}
\frac{\partial \Gamma_3}{\partial \gamma} &= (\kappa \Gamma_1)^\omega \left[\omega \Gamma_2^{\omega-1} \frac{\partial \Gamma_2}{\partial \theta} \frac{\partial \theta}{\partial \gamma} A^{-\frac{\omega}{k}} - \frac{\omega}{k} A^{-\frac{\omega}{k}-1} \Gamma_2^\omega \frac{\partial A}{\partial \theta} \frac{\partial \theta}{\partial \gamma} \right] \\
&= (\kappa \Gamma_1)^\omega \omega \Gamma_2^\omega A^{-\frac{\omega}{k}} \left[\Gamma_2^{-1} \frac{\partial \Gamma_2}{\partial \theta} - \frac{1}{k} A^{-1} \frac{\partial A}{\partial \theta} \right] \frac{\partial \theta}{\partial \gamma} \\
&= (\kappa \Gamma_1)^\omega \omega \Gamma_2^\omega A^{-\frac{\omega}{k}} \left[\frac{1}{\theta} \frac{\partial \Gamma_2}{\partial \theta} - \frac{1}{k} A^{-1} \frac{2k}{\omega} \theta^{\frac{k}{\omega}-1} \right] \frac{\partial \theta}{\partial \gamma} \\
&= (\kappa \Gamma_1)^\omega \omega \Gamma_2^\omega A^{-\frac{\omega}{k}} \theta^{-1} \left[\epsilon_{\bar{a},w} - \frac{2}{\omega} \theta^{\frac{k}{\omega}} A^{-1} \right] \frac{\partial \theta}{\partial \gamma} \\
&= (\kappa \Gamma_1)^\omega \omega \Gamma_2^\omega A^{-\frac{\omega}{k}} \theta^{-1} \left[\epsilon_{\bar{a},w} - \frac{1}{\omega} \frac{A+1}{A} \right] \frac{\partial \theta}{\partial \gamma}.
\end{aligned}$$

Noting that $0 < \omega \leq 1$, $\epsilon_{\bar{a},w} < 1$, and $\partial \theta / \partial \gamma > 0$, we obtain $\partial H / \partial \gamma < 0$.

Proof of part (v) of Proposition 1

From (33) follows $\text{sign} \frac{\partial(Y/\bar{L})}{\partial \gamma} = \text{sign} \frac{\partial(\Gamma_2 \Gamma_3)}{\partial \gamma}$. Given the parameter definitions we get:

$$\begin{aligned}
\frac{\partial(\Gamma_2 \Gamma_3)}{\partial \gamma} &= \Gamma_3 \frac{\partial \Gamma_2}{\partial \theta} \frac{\partial \theta}{\partial \gamma} + \Gamma_2 \frac{\partial \Gamma_3}{\partial \theta} \frac{\partial \theta}{\partial \gamma} \\
&= \left[\Gamma_3 \frac{\partial \Gamma_2}{\partial \theta} + (\kappa \Gamma_1)^\omega \omega \Gamma_2^\omega A^{-\frac{\omega}{k}} \left\{ \Gamma_2^{-1} \frac{\partial \Gamma_2}{\partial \theta} - \frac{1}{k} \frac{\partial A}{\partial \theta} \frac{1}{A} \right\} \Gamma_2 \right] \frac{\partial \theta}{\partial \gamma} \\
&= \left[\epsilon_{\bar{a},w} \frac{\Gamma_2}{\theta} \Gamma_3 + (\kappa \Gamma_1)^\omega \omega \Gamma_2^\omega A^{-\frac{\omega}{k}} \left\{ \frac{1}{\theta} \epsilon_{\bar{a},w} - \frac{1}{k} \frac{\partial A}{\partial \theta} \frac{1}{A} \right\} \Gamma_2 \right] \frac{\partial \theta}{\partial \gamma} \\
&= \frac{\Gamma_2}{\theta} \left[\epsilon_{\bar{a},w} \Gamma_3 + \omega (\kappa \Gamma_1 \Gamma_2)^\omega A^{-\frac{\omega}{k}} \left\{ \epsilon_{\bar{a},w} - \frac{\theta}{k} \frac{\partial A}{\partial \theta} \frac{1}{A} \right\} \right] \frac{\partial \theta}{\partial \gamma} \\
&= \frac{\Gamma_2}{\theta} \left[\epsilon_{\bar{a},w} \Gamma_3 + \omega \Gamma_3 \left\{ \epsilon_{\bar{a},w} - \frac{\theta}{k} \frac{2k}{\omega} \theta^{\frac{k}{\omega}-1} \frac{1}{A} \right\} \right] \frac{\partial \theta}{\partial \gamma} \\
&= \frac{\Gamma_2 \Gamma_3}{\theta} \left[\epsilon_{\bar{a},w} (1 + \omega) - \frac{A+1}{A} \right] \frac{\partial \theta}{\partial \gamma}
\end{aligned}$$

This yields:

$$\begin{aligned}
\frac{\partial(Y/\bar{L})}{\partial \gamma} &< 0 \quad \text{for} \quad \epsilon_{\bar{a},w} (1 + \omega) < \frac{A+1}{A} \\
\frac{\partial(Y/\bar{L})}{\partial \gamma} &> 0 \quad \text{for} \quad \epsilon_{\bar{a},w} (1 + \omega) > \frac{A+1}{A}.
\end{aligned}$$

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