# Chapter 2
# International Trade and Unemployment: The Worker-Selection Effect

## 2.1 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., 2011b; Helpman and Itskhoki, 2010), efficiency wages (Davis and Harrigan, 2011; Egger and Kreickemeier, 2009a), 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, Bazen and Cardebat (2001), Biscourp and Kramarz (2007) and Wood (1995), 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 chapter 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

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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 unemployment 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, Helpman et al. (2010a,b) and Larch and Lechthaler (2011) 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 apply for all jobs and accept any job offer, 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 Caselli 1999; Dunne et al. 2004; Kremer and Maskin 1996). In our model, workers know their abilities, each worker chooses a reservation wage, and he or she does not apply for jobs paying less than that. 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 mark-up 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 Bayard and Troske 1999; Munch and Skaksen 2008). 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 initiates an intensification of FS and improves the average entrepreneurial productivity in the economy. Hence, the FRW 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 FS 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. Bas (2012) and Yeaple (2005) 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 chapter is as follows. In Sect. 2.2, we present the set-up of the model at the sectoral level, while the general equilibrium will be derived in Sect. 2.3. In Sects. 2.4 and 2.5, we discuss the macroeconomic effects of a switch from autarky to trade and of trade liberalization, respectively. Section 2.6 concludes.

## 2.2 Model

### 2.2.1 Set-Up

Our model builds on the standard monopolistic competition model with heterogenous 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.

The production technology of the final goods producer is assumed to be a CES aggregate of all the available intermediate goods:

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

where $P$ is the corresponding price index. $V$ denotes the mass of all potentially available goods $M$ and $\sigma$ 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 $\upsilon$ can be derived from the profit maximization of the final goods producers:

$$q(\nu) = \frac{Y}{M} (p(\nu))^{-\sigma}. \tag{2.1}$$

In the intermediate goods sector there is a continuum of ex ante homogenous firms. Firms enter the differentiated sector by paying a fixed entry cost $f_e > 0$ (measured in units of final goods). They observe their productivity $\phi$, 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 $\phi$ 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 $\overline{L}$, who differ in their abilities $a_j$, $j = 1, \ldots, \overline{L}$. 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,

[1] The 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 Krugman 1980; Melitz 2003) and allows us to find new insights concerning the trade–welfare relationship.

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 $\phi_i$. The production technology is given by:

$$q_i = h_i \phi_i \overline{a}_i, \tag{2.2}$$

where $h_i$ and $\overline{a}_i$ 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 $\phi$. For concreteness, we assume:

$$a_i^* = \phi_i^\alpha \qquad \text{with} \qquad \alpha \geq 0. \tag{2.3}$$

Equation (2.3) 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 $\alpha$ denotes the sensitivity of $a_i^*$ with respect to the entrepreneurial productivity.

Assumption (2.3) is motivated by both empirical and theoretical studies. Caselli (1999), Dunne et al. (2004) and Kremer and Maskin (1996) 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 Mc Donald'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. A prominent theoretical study on this issue is Albrecht and Vroman (2002), who construct a matching model of the labor market that incorporates both skill differences across workers and differences in skill requirements across jobs. In particular, firms create jobs and for each job they choose a skill requirement in order to maximize the value of the vacancy. Helpman et al. (2010a,b) assume that by paying a screening cost, a firm can identify workers with an ability below a threshold. And since a firm does not employ workers with abilities less than this threshold, they get a minimum quality requirement which is increasing in the (entrepreneurial) productivity of the firm. In a similar vein, Uren and Virag (2011) develop a model where the required skills vary across jobs, and the greater the productivity of the firm the greater is the required skill.

The wage offer matters. Just as a firm might not want to hire a low-ability worker, a worker might not want to work for a low-wage firm. Individuals differ with respect to their reservation wage. The higher the ability of an individual, the higher is the marginal product of labor, and the higher is the reservation wage. A worker does not apply for jobs paying less than his/her reservation wage.

As a result, 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 who is indifferent between (short-term) unemployment and employment in firm $i$. We define this worker as employee $z_i$ with ability $a_{z_i}$ and reservation wage $b_{z_i}$. For $w_i = b_{z_i}$, firm $i$ attracts workers with abilities $a \leq a_{z_i}$, workers with $a > a_{z_i}$ do not apply for a job in firm $i$. Note that a firm is able to influence the upper bound of employees' abilities by offering a higher wage: $\partial a_{z_i}/\partial w_i > 0$.

The abilities of firm $i$'s employees lie within the interval $a_i^*$ and $a_{z_i}$, where the limits depend on the productivity $\phi_i$ and the wage rate $w_i$. The average ability of the firm-specific interval is given by (see Appendix A.1):

$$\overline{a}_i = \Gamma_1 \frac{\left(a_i^*\right)^{1-k} - \left(a_{z_i}\right)^{1-k}}{\left(a_i^*\right)^{-k} - \left(a_{z_i}\right)^{-k}} \qquad \text{with} \qquad \Gamma_1 \equiv \frac{k}{k-1}, \tag{2.4}$$

where $\partial \overline{a}_i/\partial a_{z_i} > 0$. A wage increase swells $a_{z_i}$ and thus the average ability.

The determination of employment and wages at the sectoral level is modeled 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 $\phi_i$. Given $\phi_i$, 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 is 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 collect information about job vacancies. Information gathering is costless, so that all workers have perfect knowledge of all job descriptions. If the marginal costs of applications are zero, the optimal strategy of a worker $j$ with ability $a_j$ is to apply for all jobs with a minimum quality requirement $a_i^* \leq a_j$ and a wage offer no less than his or her reservation wage. Any firm $i$ thus obtains a full distribution of abilities between the limits $a_i^*$ and $a_{z_i}$. To extract an economic rent, the applicants form a trade union at the firm level. The membership of union $i$ is denoted by $n_i$. Note that a worker will only apply for those vacancies s/he expects s/he will accept. Consequently, a worker accepts the offer of any job for which s/he has applied (see Layard et al. 1991).

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 randomly draws workers from among the union members until $h_i$ is reached. Since all union members fulfill the minimum quality requirement and all the union members accept the job offer, there will be a "drawing without repetition". We abstract from a (costly) screening technology. Firms are assumed to be able to observe the minimum ability of a worker at no cost, but they are not able to observe the exact value of $a_j$ of an individual worker. Furthermore, note that the existence of unions eliminates any wage differentiation within firms.

### 2.2.2 Labor Demand

We begin by discussing stage five, where $w_i$, $a_{z_i}$, $a_i^*$, and $\overline{a}_i$ 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 (2.1). Thus, the firm's revenue $r_i = q_i p_i$ is given by:

$$r_i = q_i^{\kappa} (Y/M)^{1/\sigma}, \qquad \kappa \equiv 1 - \frac{1}{\sigma}, \tag{2.5}$$

where $\kappa$ 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 the marginal costs: $\partial r_i / \partial h_i = w_i$. The optimal level of employment is given by:

$$h_i = \left( \frac{\kappa \phi_i^{\kappa} \overline{a}_i^{\kappa}}{w_i} \right)^{\sigma} \frac{Y}{M}, \tag{2.6}$$

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

$$p_i = \frac{1}{\kappa} \frac{w_i}{\phi_i \overline{a}_i} \tag{2.7}$$

is a constant mark-up $1/\kappa$ over marginal costs.

### 2.2.3 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 $a_{z_i}$. The union maximizes the expected utility of the median member $m_i$ (see Booth 1984), the objective function is given by:

$$EU_{m_i} = \frac{h_i}{n_i} w_i + \left( 1 - \frac{h_i}{n_i} \right) b_{m_i}, \tag{2.8}$$

with $b_{m_i}$ denoting the reservation wage (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 bargain, $w_i$ is chosen to maximize the Nash product

$$NP_i = \left( EU_{m_i} - \overline{U}_{m_i} \right)^{\gamma} (\pi_i - \overline{\pi}_i)^{1-\gamma},$$

with $\gamma$ $(0 \leq \gamma \leq 1)$ 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 $\overline{U}_{m_i} = b_{m_i}$ and $\overline{\pi}_i = -f$, respectively. Substituting (2.8), the firm's profit $\pi_i = r_i - h_i w_i - f$ and the threat points in the Nash product implies $NP_i = (h_i (w_i - b_{m_i})/n_i)^{\gamma} (r_i - h_i w_i)^{1-\gamma}$. The solution of the optimization problem leads to a well-known result: the wage $w_i$ is a mark-up $\theta_i$ over the median member's fallback income:

$$w_i = \theta_i b_{m_i} \qquad \text{with} \quad \theta_i \equiv \frac{\gamma + \kappa (1-\gamma)(1-\epsilon_{\overline{a}_i, w_i})}{\gamma\kappa + \kappa (1-\gamma)(1-\epsilon_{\overline{a}_i, w_i})} \geq 1. \tag{2.9}$$

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 $b_{m_i}$. The wage mark-up $\theta_i$ is increasing in the union's bargaining power and decreasing in the degree of competitiveness in the market for intermediate goods. In the case of perfect competition ($\kappa \to 1$), there is no economic rent, the mark-up converges to unity. Moreover, the mark-up is increasing in the wage elasticity of average ability, $\epsilon_{\overline{a}_i, w_i}$, which is defined as $\epsilon_{\overline{a}_i, w_i} \equiv \frac{\partial \overline{a}_i}{\partial w_i} \frac{w_i}{\overline{a}_i}$. The higher the increase in the average ability as response to a wage hike, the better is the trade-off between jobs and wages facing the union and the higher is the bargained wage (see Garino and Martin 2000). Of course, the elasticity is endogenous, we take up this issue in Sect. 2.3.1.

We complete the analysis of stage four by the derivation of the fallback income of worker $j$ with ability $a_j$. If worker $j$ is the median member of firm $i$, we have $j = m_i$. Worker $j$ can be either employed or unemployed. The value functions are:

$$V_j = \frac{1}{1+\rho} \left[ \overline{w}_j + (1-\delta) V_j + \delta V_j^u \right]$$

$$V_j^u = \frac{1}{1+\rho} \left[ e_j V_j + \left(1 - e_j\right) V_j^u \right],$$

where $\rho$ represents the discount factor and $\delta$ denotes the probability of the firm's death (exogenous and independent of productivity). Therefore, $\delta$ can also be interpreted as the probability of job loss for any employee. The likelihood that worker $j$ will switch from unemployment to a job is captured by $e_j$. For analytical simplicity, we normalize the marginal utility of leisure and the UB to zero. The fallback income is defined as the period income of an unemployed worker: $b_j \equiv \rho V_j^u$ (see Layard and Nickell 1990). From the value functions we obtain $b_j = \frac{e_j}{\rho + \delta + e_j} \overline{w}_j$.

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

$$\delta \left(1 - u_j\right) = e_j u_j. \tag{2.10}$$

Entrepreneurial productivity and workers' abilities are both Pareto distributed with identical lower bounds and shape parameter $k$. These characteristics, combined with the assumption of a random matching, 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:

$$u = u_j = 1 - \frac{H_j}{L_j} \qquad \forall j. \tag{2.11}$$

By using (2.10) and (2.11) the fallback income can be derived as[2]:

$$b_j = (1-u)\overline{w}_j. \tag{2.12}$$

As already mentioned, the fallback income of worker $j$ corresponds to the reservation wage of worker $j$. The reservation wage is decreasing in the unemployment rate and increasing in the outside wage $\overline{w}_j$, which is defined as $j$'s expected wage rate in the economy.

Let us have a closer look at the outside wage. 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; Holmlund and Zetterberg 1991; Nickell and Kong 1992). We take up this observation by assuming that the outside wage is a convex combination of a microeconomic and a macroeconomic variable:

$$\overline{w}_j = \left(a_j\right)^{\omega} \left(w(\widetilde{\phi})\right)^{1-\omega} \qquad 0 \leq \omega \leq 1. \tag{2.13}$$

In our context, the most plausible microeconomic variable is the ability $a_j$ of worker $j$. The higher the skill-level of a worker, the higher is the wage s/he can expect in the economy (or: the computer scientist expects a higher wage than the collector irrespective of the state of the economy). Less obvious is the macroeconomic variable. In a world with homogeneous workers, where, by definition, individual characteristics do not matter ($\omega = 0$), consistency requires that the outside wage coincides with the wage prevailing in a (symmetric) general equilibrium (see, for instance, Layard and Nickell 1990). We pick up this scenario by assuming that the outside wage of a worker $j$ is increasing in the wage rate which holds in the general equilibrium, $w(\widetilde{\phi})$, where $\widetilde{\phi}$ denotes the entrepreneurial productivity of the representative firm (see below).[3]

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[2]Note that (2.12) is an approximation, which holds for $\rho u = 0$. For a justification of this simplifying assumption see Layard and Nickell (1990).

[3]One might argue that high-skilled workers with a reservation wage above the wage paid by the representative firm are not affected by $w(\widetilde{\phi})$. Consequently, $w(\widetilde{\phi})$ should not be part of their outside option. However, in a *Melitz*-world with pareto-distributed productivities, the aggregate variables have the property that they are identical to what they would be if the economy were endowed with $M$ identical firms with productivity $\widetilde{\phi}$. Therefore, $w(\widetilde{\phi})$ is only a shortcut for the "true" distribution

With these building blocks at hand and noting $j = m_i$, the bargained wage (2.9) can be rewritten as:

$$w_i = \theta_i \,(1-u)\,(a_{m_i})^{\omega}\left(w(\widetilde{\phi})\right)^{1-\omega}. \tag{2.14}$$

Owing to heterogeneous individuals, the economic surplus (bargained wage minus reservation wage) differs between union members. Within the firm's and the union's ability interval, the worker with the minimum qualification obtains the largest rent (lowest reservation wage). The surplus declines with members' ability levels, because of an increasing reservation wage. Member $z_i$ 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.

### 2.2.4 *Union Membership, Vacancy Posting and the Melitz Lottery*

Stage three determines union membership $n_i$. As illustrated above, all workers with ability $a_i^* \leq a \leq a_{z_i}$ apply for a job at firm $i$, so that each firm $i$ gets the full distribution of abilities within the two limits. Workers with an ability greater than $a_{z_i}$ have a reservation wage exceeding $w_i$, so they do not apply and they are not members of trade union $i$. The number of applicants and thus the number of union members is given by:

$$n_i = \int_{a_i^*}^{a_{z_i}} k a^{-(1+k)} da = \left(a_i^*\right)^{-k} - (a_{z_i})^{-k}. \tag{2.15}$$

In order to determine the ability limits we turn to the posting of the vacancy, which is the topic of stage two, where a firm's entrepreneurial productivity $\phi_i$ is already predetermined. The lower limit is obviously given by the minimum ability requirement, $a_i^* = \phi_i^{\alpha}$. The upper limit, on the other hand, is determined by the requirement that the posted wage equals the reservation wage of the efficient worker $z_i$. The posted wage is given by (2.14), the reservation wage of worker $z_i$ is given by $b_{z_i} = (1-u)\,(a_{z_i})^{\omega}\left(w(\widetilde{\phi})\right)^{1-\omega}$. From $w_i = b_{z_i}$ immediately follows $a_{z_i} = \theta_i^{1/\omega} a_{m_i}$. As shown in Appendix A.1, the ability of the median member can be derived as:

$$a_{m_i} = 2^{1/k}\left[(a_{z_i})^{-k} + \left(a_i^*\right)^{-k}\right]^{-1/k}. \tag{2.16}$$

of wages in the economy. A shift in $w(\widetilde{\phi})$ should thus be interpreted as a proxy for a shift in the whole wage distribution affecting all wages irrespective of the skill-level.

Inserting this result into $a_{z_i} = \theta_i^{1/\omega} a_{m_i}$ and noting $a_i^* = \phi_i^\alpha$, we obtain:

$$a_{z_i} = \left(2\theta_i^{k/\omega} - 1\right)^{1/k} \phi_i^\alpha. \tag{2.17}$$

If a firm knows its entrepreneurial productivity $\phi_i$, it sets a minimum ability according to (2.3) and the ability of the efficient worker is given by (2.17). Note that the ability of the efficient worker and thus the average ability is increasing in the union's bargaining power (higher wage mark-up $\theta_i$). The wage rate can now be written as:

$$w_i = \left(2\theta_i^{k/\omega} - 1\right)^{\omega/k} (1-u) \left(w(\widetilde{\phi})\right)^{1-\omega} \phi_i^{\alpha\omega}. \tag{2.18}$$

The wage $w_i$ is increasing in the entrepreneurial productivity $\phi_i$. High-productivity firms have to pay higher wages than 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, Bayard and Troske 1999; Munch and Skaksen 2008).

In stage one, firm $i$ participates in the *Melitz* lottery and draws the entrepreneurial productivity $\phi_i$. 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 (henceforth FE) and the zero cut-off profit condition (henceforth ZPC) (see Melitz 2003). We follow Egger and Kreickemeier (2009a) and derive from these conditions the cut-off productivity level:

$$\phi^* = \left(\frac{f\beta}{(k-\beta)\, f_e \delta}\right)^{1/k} \tag{2.19}$$

with $\beta \equiv (\sigma - 1)(1 + \alpha - \alpha\omega) > 0$ and $\phi^*$ 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 $\gamma$ have no impact on the cut-off productivity $\phi^*$. For a similar result, see Eckel and Egger (2009).

The existence of such a marginal firm with productivity $\phi^*$ 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 (2.3), we obtain:

$$a^* = \left(\phi^*\right)^\alpha. \tag{2.20}$$

Thus, we divide the labor force $\overline{L}$ into two groups: (i) active[4] 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.

## 2.3 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.

### *2.3.1 Average Productivity and Aggregation*

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

$$\widetilde{\phi} = \left[\frac{k}{k-\beta}\right]^{1/\beta} \phi^*, \qquad k > \beta. \tag{2.21}$$

The derivation of (2.21) makes use of the fact that the wage elasticity of average ability, $\epsilon_{\overline{a}_i,w_i}$, and thus the wage mark-up $\theta_i$ is identical across all firms: $\epsilon_{\overline{a}_i,w_i} = \epsilon_{\overline{a},w}$ and $\theta_i = \theta$ for all $i$ (see Appendix A.2).

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

$$H = Mh(\widetilde{\phi})\xi_1\xi_2; \text{ with } \xi_1 \equiv \left[\frac{k}{k-\beta}\right]^{\alpha\omega/\beta}, \quad \xi_2 \equiv \frac{k-\beta}{k-\beta+\alpha\omega}. \tag{2.22}$$

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 $\overline{u}$ 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 obtain $\overline{u} = u^l \frac{L^l}{\overline{L}} + u\frac{L}{\overline{L}} = 1 \cdot (1 - (a^*)^{-k}) + u \cdot (a^*)^{-k} = 1 - (1-u)(a^*)^{-k}$. Noting that $u = 1 - H/L$, the aggregate unemployment rate simplifies to:

[4]"Active" means that these workers have a positive employment probability. Nevertheless, at any point in time a fraction of active workers is unemployed.

$$\overline{u} = 1 - \left(a^*\right)^{-k} \frac{H}{L}. \tag{2.23}$$

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 $P$, $Y$, $R$, $\Pi$, and $H$ are identical to what they would be if the economy were endowed with $M$ identical firms with productivity $\widetilde{\phi}$. Therefore, we treat the firm with productivity $\widetilde{\phi}$ as the representative firm for the economy.

### *2.3.2 Equilibrium (Long-Term) 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 $p(\widetilde{\phi}) = 1$. Then, the price rule (2.7) delivers the FRW:

$$w_{PS}(\widetilde{\phi}) = \kappa \overline{a}(\widetilde{\phi}, \theta) \cdot \widetilde{\phi}. \tag{2.24}$$

The FRW 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 FRW is positively affected by trade unions. More powerful trade unions increase the wage mark-up $\theta$, which in turn increases the ability of the efficient worker (see (2.17)), and thus the average ability $\overline{a}$ (see (2.4)), and thus the FRW.

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 (2.18). Taking the macroeconomic variables as given, the target real wage of the representative union can be written as:

$$w_{WS}(\widetilde{\phi}) = \left(2\theta^{k/\omega} - 1\right)^{\omega/k} \cdot \left(w(\widetilde{\phi})\right)^{1-\omega} (1-u) \cdot \widetilde{\phi}^{\alpha\omega}. \tag{2.25}$$

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 $w_{PS}(\widetilde{\phi}) = w_{WS}(\widetilde{\phi}) = w(\widetilde{\phi})$. By combining (2.24) and (2.25), we can compute the unemployment rate of the active workers as (see Appendix A.3):

$$u = 1 - \Gamma_3 \cdot \widetilde{\phi}^{\omega}, \tag{2.26}$$

where $\Gamma_3$ is a positive constant defined in Appendix A.3. Note that the rate of unemployment of active workers is decreasing in the average productivity $\widetilde{\phi}$ and independent of the labor force $\overline{L}$.[5]

In a next step, we derive the number of long-term unemployed, $L^l$. Inserting (2.20) and (2.21) into $L^l = (1-(a^*)^{-k})\overline{L}$ produces:

$$L^l = \left(1 - \xi_3 \cdot \widetilde{\phi}^{-\alpha k}\right)\overline{L} \qquad \text{with} \qquad \xi_3 \equiv \left(\frac{k}{k-\beta}\right)^{\alpha k/\beta}. \tag{2.27}$$

An increase in the cut-off productivity $\phi^*$, which translates into an increase in the average productivity $\widetilde{\phi}$, leads to a rise in workers' minimum quality requirement, see (2.20). 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 $\phi^*$ (high $\alpha$), the stronger is the worker-selection effect.

The number of active workers is straightforward to derive:

$$L = \overline{L} - L^l = \xi_3 \cdot \widetilde{\phi}^{-\alpha k} \cdot \overline{L}. \tag{2.28}$$

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

$$H = \xi_3 \Gamma_3 \cdot \widetilde{\phi}^{\omega - \alpha k} \cdot \overline{L}. \tag{2.29}$$

The employment effect of higher entrepreneurial productivity is ambiguous. We identify three channels through which a higher $\widetilde{\phi}$ affects employment: the FRW, the target real wage and the worker-selection effect. However, we postpone the discussion of these effects to Sect. 2.4.2.

The aggregate unemployment rate $\overline{u}$ turns out to be:

$$\overline{u} = 1 - \xi_3 \Gamma_3 \cdot \widetilde{\phi}^{\omega - \alpha k}. \tag{2.30}$$

Next, we derive the level of welfare. We choose per capita output $Y/\overline{L}$ 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 mark-up pricing rule, the per capita wage income is then equal to a constant share $\kappa$ of per capita output: $W/\overline{L} = \kappa Y/\overline{L}$.

[5] To ensure $0 \leq u \leq 1$, we have to assume $\Gamma_3 \cdot \widetilde{\phi}^{\omega} \leq 1$, i.e., aggregate labor demand $H$ must not exceed the number of active workers $L$. The higher the shape parameter $k$, the larger is the fraction of firms with an entrepreneurial productivity close to the cut off level, the larger is the fraction of firms with a relatively low minimum quality requirement, and the larger is the number of active workers. If $k$ exceeds a well-defined threshold, the condition $H < L$ is fulfilled (for a similar problem and solution see Egger and Kreickemeier 2009a).

Using the technology assumption (2.2) and (2.22), the per capita output is $Y/\overline{L} = Mq(\widetilde{\phi})/\overline{L} = Mh(\widetilde{\phi})\overline{a}(\widetilde{\phi},\theta)\widetilde{\phi}/\overline{L} = H\overline{a}(\widetilde{\phi},\theta)\widetilde{\phi}/(\xi_1\xi_2\overline{L})$. Now insert (2.29) and (2.57) (see Appendix A.3) to arrive at:

$$\frac{Y}{\overline{L}} = \frac{\Gamma_1\Gamma_2\Gamma_3\xi_3}{\xi_1\xi_2} \cdot \widetilde{\phi}^{1+\alpha+\omega-\alpha k}. \tag{2.31}$$

Finally, we consider the distribution of wages in the general equilibrium. Following Egger and Kreickemeier (2009a), we choose the ratio of the average wage rate, $\overline{w}$, to the lowest wage rate, $w(\phi^*)$, as measure of wage inequality. The average wage rate is defined by $\overline{w} \equiv W/H = \kappa Y/H$. Observing $Y = Mq(\widetilde{\phi})$, (2.2), (2.22) and (2.24) yields $\overline{w} = w(\widetilde{\phi})/\xi_1\xi_2$. By combining (2.18) with (2.21) the lowest wage can be computed as $w(\phi^*) = w(\widetilde{\phi})/\xi_1$. Consequently, our measure of wage inequality is given by:

$$\frac{\overline{w}}{w(\phi^*)} = \frac{1}{\xi_2} = \frac{k-\beta+\alpha\omega}{k-\beta}. \tag{2.32}$$

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 (2.19) and (2.21), $\phi^*$ and $\widetilde{\phi}$ 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 mark-up $\theta$ goes up, i.e. 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 mark-up $\theta$ 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 FRW 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 $\epsilon_{\overline{a},w}\,(1+\omega) - \frac{A+1}{A}$. The results are summarized in:

**Proposition 2.1.** *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*

$\epsilon_{\overline{a},w}(1+\omega) > \frac{A+1}{A}$ *output and welfare increase, but for* $\epsilon_{\overline{a},w}(1+\omega) < \frac{A+1}{A}$ *output and welfare decrease.*

*Proof.* see text and Appendix A.4. ■

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

$$M = \frac{k-\beta}{fk\sigma}Y.$$

The stability of the equilibrium turns out to be a crucial issue. In the *Melitz* model, marginal costs (the wage) are given to the firm. A firm with a productivity lower than $\phi^*$ does not sell enough to cover fixed costs, the firm does not enter the market. In our model, however, the wage and therefore marginal costs are at the disposal of the firm. The marginal firm with $\phi_i = \phi^*$ may thus have an incentive to lower the wage and the price in order to attract additional demand. By lowering the wage, the marginal firm looses its most efficient workers, but the number of applicants does not drop to zero. Workers with ability $a^*$ fulfill the minimum quality requirement of the marginal firm and they are willing to work for any positive wage, since their only alternative is long-term unemployment with zero utility. Similarly, a firm with $\phi_i < \phi^*$ posts vacancies with $w_i < w(\phi^*)$ and still gets applicants. In such a scenario long-term unemployment may vanish.

But we do not find this scenario very plausible. Our justification of the existence of long-term unemployment is twofold. First, long-term unemployment is a matter of fact. Second, the incorporation of efficiency wage considerations would immediately provide a microeconomic rationale for a wage rigidity at the wage $w(\phi^*)$. Suppose the technology (2.2) is extended by an effort function: $q_i = h_i\phi_i\overline{a}_i e_i$ with effort $e_i = e_i(\frac{w_i}{w(\phi^*)})$. Workers evaluate a firm's wage offer by comparison with $w(\phi^*)$ as wage reference. For $w_i > w(\phi^*)$ worker increase effort, for $w_i < w(\phi^*)$ worker decrease effort compared to a reference level, which we normalize to one. Most important, at least from our point of view, is the growing empirical evidence that the response to wage changes is highly asymmetric. As the literature on reciprocity in labor relations indicates, wage increases have a weak effect, while wage cuts led to a strong decline in effort (see, e.g., Chemin et al. 2011; Cohn et al. 2011; Danthine and Kurman 2007; Kube et al. 2010). We put this observation to the extreme by assuming that a wage $w_i$ higher than $w(\phi^*)$ has no impact on effort, $e_i$ remains constant at unity. By contrast, a decline in the wage below the reference level leads to a strong decline in effort. To be more precise, we assume that the wage elasticity of the effort function is (at least) one. In this case, the marginal firm with $\phi_i = \phi^*$ and $w_i = w(\phi^*)$ does not have an incentive to lower the wage. Due to the decline in effort, there will be no decline in marginal costs.

No doubt, extending the model by incorporating efficiency wages has a value added. But, balancing the value added with the loss of analytical tractability, we decided to postpone this issue to further research.

## 2.4 Open Economy

### 2.4.1 Modifications

We now turn to an open economy setting with two symmetric countries.[6] 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 Sect. 2.2. 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 $\pi_x\left(\phi_x^*\right) = 0$, 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:

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

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

$$\widetilde{\phi}_t = \widetilde{\phi}\left[\frac{1}{1+\chi}\left(1 + \chi\tau^{1-\sigma}\left(\frac{\widetilde{\phi}_x}{\widetilde{\phi}}\right)^\beta\right)\right]^{1/\beta}, \tag{2.33}$$

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

$$\widetilde{\phi}_x = \left[\frac{k}{k-\beta}\right]^{1/\beta} \phi_x^* \tag{2.34}$$

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

$$\widetilde{\phi} = \left[\frac{k}{k-\beta}\right]^{1/\beta} \phi^*. \tag{2.35}$$

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, $\widetilde{\phi}$, is equal to the average productivity of all firms active in a country, $\widetilde{\phi}_t$ (see Egger and Kreickemeier 2009a). Formally, we use $f_x = f$, the ZPC, (2.34) and (2.35) to obtain:

$$\left(\frac{\phi_x^*}{\phi^*}\right)^{\beta} = \left(\frac{\widetilde{\phi}_x}{\widetilde{\phi}}\right)^{\beta} = \tau^{\sigma-1}. \tag{2.36}$$

Substituting (2.36) into (2.33) leads to $\widetilde{\phi}_t = \widetilde{\phi}$. Furthermore, (2.36) 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: $P = p(\widetilde{\phi}_t) \equiv 1$, $Y = M_t q(\widetilde{\phi}_t)$, $R = M_t r(\widetilde{\phi}_t)$ and $\Pi = M_t \pi(\widetilde{\phi}_t)$. Moreover, note that $M_t = M\,(1+\chi)$. For the employment level, we get:

$$H = h(\widetilde{\phi}_t)\xi_1\xi_2\psi_1, \tag{2.37}$$

where $\psi_1 \equiv M + M_x\left(\phi^*/\phi_x^*\right)^{\alpha\omega} = M + M_x\tau^{-\alpha\omega/(1+\alpha-\alpha\omega)}$. For a given level of $\widetilde{\phi}_t$, 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 $\tau$.

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

$$w_{PS}(\widetilde{\phi}_t) = \kappa\overline{a}(\widetilde{\phi}_t)\cdot\widetilde{\phi}_t \tag{2.38}$$

$$w_{WS}(\widetilde{\phi}_t) = \left(2\theta^{k/\omega}-1\right)^{\omega/k}\cdot\left(w(\widetilde{\phi}_t)\right)^{1-\omega}(1-u)\cdot\widetilde{\phi}_t^{\alpha\omega}. \tag{2.39}$$

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 $\overline{u}$ can be computed as:

$$u = 1 - \Gamma_3\cdot\widetilde{\phi}_t^{\omega} \tag{2.40}$$

$$L = \xi_3\cdot\widetilde{\phi}_t^{-\alpha k}\cdot\overline{L} \tag{2.41}$$

$$H = \Gamma_3\cdot\widetilde{\phi}_t^{1-(1-\omega)-\alpha k}\cdot\overline{L} \tag{2.42}$$

$$L^l = \left(1 - \xi_3 \cdot \widetilde{\phi}_t^{-\alpha k}\right) \overline{L} \tag{2.43}$$

$$\overline{u} = 1 - \xi_3 \Gamma_3 \cdot \widetilde{\phi}_t^{\omega - \alpha k}. \tag{2.44}$$

Welfare is then given by $Y/\overline{L} = M_t q(\widetilde{\phi}_t)/\overline{L} = M_t h(\widetilde{\phi}_t)\overline{a}(\widetilde{\phi}_t, \theta)\widetilde{\phi}_t/\overline{L} = M_t \frac{\overline{a}(\widetilde{\phi}_t, \theta)\widetilde{\phi}_t}{\xi_1 \xi_2 \psi_1} \frac{H}{\overline{L}}$. Observing the definition of $\psi_1$ as well as (2.42) and $\overline{a} = \Gamma_1 \Gamma_2 \widetilde{\phi}_t^{\alpha}$ from (2.57) in Appendix A.3, we get:

$$\frac{Y}{\overline{L}} = \psi_2 \cdot \frac{\Gamma_1 \Gamma_2 \Gamma_3 \xi_3}{\xi_1 \xi_2} \cdot \widetilde{\phi}_t^{1+\alpha+\omega-\alpha k} \tag{2.45}$$

with

$$\psi_2 \equiv \frac{1 + \chi}{1 + \chi^{(\alpha\omega + k)/k}} > 1. \tag{2.46}$$

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

$$\frac{\overline{w}}{w(\phi^*)} = \psi_2 \cdot \frac{k - \beta + \alpha\omega}{k - \beta}. \tag{2.47}$$

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

$$\phi^* = \left[\frac{f\beta\,(1 + \chi)}{(k - \beta)\, f_e \delta}\right]^{1/k}. \tag{2.48}$$

## 2.4.2 *Autarky Versus Trade: Macroeconomic Implications*

The transition from autarky to trade causes the well-known FS effect (see Melitz 2003), which occurs because of an increase in the cut-off productivity $\phi^*$. 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 (2.19), (2.21), (2.35), (2.48) and $\widetilde{\phi}_t = \widetilde{\phi}$, we conclude that there is an increasing average productivity of all active firms:

$$\frac{\widetilde{\phi}_t}{\widetilde{\phi}_a} = \frac{\phi^*}{\phi_a^*} = (1 + \chi)^{1/k} > 1, \tag{2.49}$$

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 (2.27) with (2.43) and (2.28) with (2.41), 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 $\alpha$, the stronger is the worker-selection effect.

The worker-selection effect also reduces employment $H$ (see (2.41)). But there are two additional effects. The increase in average productivity $\widetilde{\phi}_t$ reduces the marginal costs of the representative firm, shifting up the FRW 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 (2.3), 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 (2.13)), 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 $\omega$, high $1-\omega$), unions respond to the increase in the FRW with a nearly proportional increase in the target real wage. For $\omega = 0$, the combined effect on the FRW 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 (2.42). For $0 < \omega < \alpha k$, the rise in the FRW 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 (2.40). 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 $\overline{u}$. The reason is clear: due to the worker-selection effect, some active workers switch to long-term unemployment ($u$ declines but $\overline{u}$ rises). As indicated by (2.44), the condition for the change in $\overline{u}$ 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 $\overline{u}$, vice versa. To be more precise, for $\omega > \alpha k$ employment $H$ rises ($\overline{u}$ declines), whereas for $\omega < \alpha k$ employment declines ($\overline{u}$ rises). We summarize all these results in:

**Proposition 2.2.** *Suppose that an economy switches from autarky to trade. Then, higher average entrepreneurial productivity $\widetilde{\phi}_t$ 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 FRW, 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 FRW 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 2.3.** *(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 $\widetilde{\phi}_t/\widetilde{\phi}_a = (1+\chi)^{1/k} > 1$ from (2.49), the ratio of welfare in the open-economy setting (2.45) and welfare in autarky (2.31) 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 (2.46)), 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 (2.2), 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 $\alpha$. If these two positive effects on output exceed the negative employment effect, $1+\alpha > \alpha k - \omega$, welfare improves (part (ii) of Proposition 2.3). 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 (2.32) and (2.47), it follows that the wage differential $\overline{w}/w(\phi^*)$ 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 (2009a).

## 2.5 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, i.e. 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 (2.36) that the probability of being an exporter is decreasing in the iceberg costs, $\chi = \tau^{-k/(1+\alpha-\alpha\omega)}$. A lower $\tau$ leads to a larger fraction of exporters. Moreover, due to a higher degree of competition, the domestic cut-off productivity $\phi^*$ increases, see (2.48). This translates into an increase in the average productivities $\widetilde{\phi}$ and $\widetilde{\phi}_t$. For the employment effects, we thus get the same results as in the case of a switch from autarky to trade.

**Proposition 2.4.** *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, $ak < \omega$, aggregate employment improves, and (ii) for a strong worker-selection effect, $ak > \omega$, aggregate employment declines.*

*Proof.* See Proposition 2.3 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 FS effect, which increases productivity, but lowers employment. This is in contrast to, for instance, Dutt et al. (2009) and Felbermayr et al. (2011a), 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 (2.45) with respect to iceberg costs, we have:

$$sign\left(\frac{\partial(Y/\overline{L})}{\partial\tau}\right) = sign\left[\psi_2(1+\alpha+\omega-\alpha k)\frac{\partial\widetilde{\phi}_t}{\partial\tau} + \widetilde{\phi}_t\frac{\partial\psi_2}{\partial\tau}\right]. \tag{2.50}$$

The first summand in the square brackets replicates the trade openness scenario. A reduction in iceberg costs increases the cut-off and average productivity, $\phi^*$ and $\widetilde{\phi}_t$, respectively. Noting $\partial\widetilde{\phi}_t/\partial\tau < 0$, the first summand is negative if the worker-selection effect is weak, i.e. 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 2.3).

But in the case of trade liberalization we observe an additional effect, reflected in the second summand in the square brackets of (2.50). The composition of firms changes by virtue of $\psi_2$. 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 $\psi_2$). On the other hand, the productivity cut-off increases, which forces the least productive firms out of the market and welfare decreases (lower $\psi_2$). Formally, we can use $\chi = \tau^{k/(\alpha(\omega-1)-1)}$ and (2.36) to identify a critical $\overline{\tau} > 1$ (see Egger and Kreickemeier 2009a):

$$sign\left(\frac{\partial\psi_2}{\partial\tau}\right) = sign\left[\alpha\omega - \frac{k\left(\tau^{\frac{\alpha\omega}{1+\alpha-\alpha\omega}} - 1\right)}{1+\tau^{\frac{-k}{1+\alpha-\alpha\omega}}}\right]. \tag{2.51}$$

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

**Proposition 2.5.** *(i) If the worker-selection effect is weak and iceberg costs are low, $1+\alpha+\omega-\alpha k > 0$ and $\tau < \overline{\tau}$, trade liberalization increases welfare. (ii) If the worker-selection effect is strong and iceberg costs are high, $1+\alpha+\omega-\alpha k < 0$ and $\tau > \overline{\tau}$, trade liberalization lowers welfare. (iii) In all other cases the welfare effect is ambiguous.*

Finally, we use (2.47) to analyze the effect of trade liberalization on wage distribution. A reduction of $\tau$ 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 $\psi_2$). 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 $\psi_2$). Combining these effects, we find (see Egger and Kreickemeier 2009a, for a similar result):

**Proposition 2.6.** *(i) If iceberg costs are low, $\tau < \overline{\tau}$, trade liberalization increases wage inequality, whereas, (ii) if iceberg costs are high, $\tau > \overline{\tau}$, trade liberalization reduces wage inequality.*

The predictions of our model concerning employment and welfare very much depend on the parameters $\omega$, $\alpha$ 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 $\omega$, measuring the weight of the abilities in the wage determination, has been estimated only in a few studies. Keane (1993) claims that 84 % of wage differences across industries are explained by individual fixed effects, while only 16 % 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 $\alpha$, which captures the strength of the minimum quality requirements. Intuitively, $\alpha$ 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 $\alpha k$. Note, however, that our model does not allow for a love of variety effect and thus underestimates the welfare effect.

## 2.6 Conclusion

This chapter 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 most plausible 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).

# Appendix

## *A.1 Appendix 1*

**Derivation of the Average Ability (2.4):** 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:

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

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

$$\zeta(a) = \frac{\mu_a(a)}{\Omega_a(a_{z_i}) - \Omega_a(a_i^*)} = \frac{ka^{-k-1}}{(a_i^*)^{-k} - (a_{z_i})^{-k}} \qquad \text{for} \qquad a_i^* \le a \le a_{z_i}. \tag{2.52}$$

Next, we compute the expected value of (2.52), which immediately leads to Eq. (2.4) in the text.

**Derivation of the Ability of the Median Member (2.16):** To obtain the median of the ability interval $(a_i^*, a_{z_i})$, we first calculate the corresponding distribution function of (2.52):

$$Z(a) = \int_{a_i^*}^{a_{z_i}} \zeta(a)\, da = \frac{a^{-k} - (a_i^*)^{-k}}{(a_{z_i})^{-k} - (a_i^*)^{-k}}. \tag{2.53}$$

Next, we convert $Z(a)$ into the quantile function, which equals the inverse of $Z(a)$. The median $a_{m_i}$ is defined as the 0.5 quantile, $a_{m_i} = Z^{-1}(0.5)$, which leads to Eq. (2.16) in the text.

## A.2 Appendix 2

**Derivation of the Wage Elasticity of Average Ability:** From $w_i = b_{z_i} = (1-u)\overline{w}_{z_i} = (1-u)(a_{z_i})^{\omega}\left(w(\widetilde{\phi})\right)^{1-\omega}$ we get $\partial a_{z_i}/\partial w_i = a_{z_i}/\omega w_i$. Inserting this result into the definition $\epsilon_{\overline{a}_i,w_i} = \frac{w_i}{\overline{a}_i}\frac{\partial \overline{a}_i}{\partial a_{z_i}}\frac{\partial a_{z_i}}{\partial w_i}$ leads to $\epsilon_{\overline{a}_i,w_i} = \epsilon_{\overline{a}_i,a_{z_i}}/\omega$ with $\epsilon_{\overline{a}_i,a_{z_i}} \equiv \frac{\partial \overline{a}_i}{\partial a_{z_i}}\frac{a_{z_i}}{\overline{a}_i}$. The elasticity $\epsilon_{\overline{a}_i,a_{z_i}}$ can be derived from (2.4):

$$\begin{aligned}\epsilon_{\overline{a}_i,a_{z_i}} &= \frac{a_{z_i}}{\overline{a}_i}\Gamma_1\left[\frac{(k-1)(a_{z_i})^{-k}}{\left(a_i^*\right)^{-k}-(a_{z_i})^{-k}} - \frac{k(a_{z_i})^{-k-1}\left(\left(a_i^*\right)^{1-k}-(a_{z_i})^{1-k}\right)}{\left(\left(a_i^*\right)^{-k}-(a_{z_i})^{-k}\right)^2}\right] \\ &= \frac{a_{z_i}}{\left(a_i^*\right)^{1-k}-(a_{z_i})^{1-k}}\left[(k-1)(a_{z_i})^{-k} - \frac{k(a_{z_i})^{-k-1}\left(\left(a_i^*\right)^{1-k}-(a_{z_i})^{1-k}\right)}{\left(a_i^*\right)^{-k}-(a_{z_i})^{-k}}\right].\end{aligned} \tag{2.54}$$

Next, insert the minimum ability (2.3) and the ability of the efficient worker (2.17) into (2.54) to arrive at:

$$\epsilon_{\overline{a}_i,a_{z_i}} = \frac{(k-1)X_i^{1-k}}{1-X_i^{1-k}} - \frac{kX_i^{-k}}{1-X_i^{-k}} \quad \text{with} \quad X_i \equiv \left(2\theta_i^{k/\omega}-1\right)^{1/k} > 1. \tag{2.55}$$

Observing $\epsilon_{\overline{a}_i,w_i} = \epsilon_{\overline{a}_i,a_{z_i}}/\omega$ and the wage mark-up (2.9), we yield a single equation determining the elasticity $\epsilon_{\overline{a}_i,w_i}$. Since all firms face the same structural parameters and since the entrepreneurial productivity does not enter into (2.55), the wage elasticity of average ability and thus the wage mark-up is identical across all firms: $\epsilon_{\overline{a}_i,w_i} = \epsilon_{\overline{a},w}$ and $\theta_i = \theta$ or all $i$. Due to non-linearities we can not derive a closed form solution for $\epsilon_{\overline{a},w}$. Simulations, however, indicate that for all meaningful (but not for all) parameter constellations the elasticity does not exceed one. In the following we thus assume $\epsilon_{\overline{a},w} \leq 1$. This assumption rules out a scenario where a wage hike leads to a decline in marginal costs and thus a decline in the profit-maximizing price.

## A.3 Appendix 3

**Derivation of the Unemployment Rate of the Active Workers (2.26):** Combine (2.24) and (2.25) to eliminate the wage. This leads to:

$$\kappa \overline{a} \widetilde{\phi} = A^{1/k}(1-u)^{1/\omega} \cdot \widetilde{\phi}^{\alpha} \qquad \text{with} \qquad A \equiv 2\theta^{k/\omega} - 1 > 1. \tag{2.56}$$

Inserting the minimum quality requirement (2.3), the upper bound of abilities (2.17) and $\phi_i = \widetilde{\phi}$ into the average ability (2.4) yields:

$$\overline{a} = \Gamma_1 \Gamma_2(\theta) \cdot \widetilde{\phi}^{\alpha} \qquad \text{with} \qquad \Gamma_2(\theta) \equiv \frac{A - A^{1/k}}{A-1}. \tag{2.57}$$

Substitute (2.57) into (2.56) and rearrange for the unemployment rate of active workers:

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

## A.4 Appendix 4

**Proof of Part (iii) of Proposition 2.1** We compute the relation between unions' bargaining power and the employment level of active workers. Remember that an increase in $\gamma$ raises the wage-mark-up $\theta$ and shifts up the wage rate, which in turn increases the average ability (2.57). From $\epsilon_{\overline{a},w} = \frac{\partial \overline{a}}{\partial w} \frac{w}{\overline{a}} = \frac{\partial \Gamma_2}{\partial \theta} \frac{\theta}{\Gamma_2} < 1$ and (2.29) follows $sign \frac{\partial H}{\partial \gamma} = sign \frac{\partial \Gamma_3}{\partial \gamma}$. Given the parameter definitions we get:

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

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

**Proof of Part (v) of Proposition 2.1** From (2.31) follows $sign\frac{\partial(Y/\overline{L})}{\partial\gamma} = sign\frac{\partial(\Gamma_2\Gamma_3)}{\partial\gamma}$. Given the parameter definitions we get:

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

This yields:

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

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