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# Unemployment Benefits as Redistribution Scheme of Trade Gains – a Positive Analysis\*

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## Abstract

Trade liberalization is no Pareto-improvement – there are winners (high-skilled) and losers (low-skilled). To compensate the losers the government is assumed to introduce unemployment benefits (UB). These benefits are financed by either a wage tax, a payroll tax, or a profit tax. Using a *Melitz*-type model of international trade with unionized labour markets and heterogeneous workers we show that: (i) UB financed by a wage tax reduce aggregate employment but increase welfare measured by per capita output. (ii) UB financed by a payroll tax reduce aggregate employment and welfare. If UB exceeds a well-defined threshold, the trade gains will be completely destroyed. (iii) UB financed by a profit tax reduce the unemployment rate of the low-skilled, but also reduces welfare. The threshold for the level of UB, where the trade gains are destroyed by the redistribution scheme, is higher compared to the case of a payroll tax.

JEL-Classification: F1, F16, H2

Keywords: trade liberalization, heterogeneous firms, trade unions, skill-specific unemployment, unemployment benefits, taxes

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# 1 Introduction

The overwhelming majority of the trade literature concludes that trade liberalization is no Pareto-improvement. Despite the gains of trade on the macroeconomic level, there are losers on the microeconomic level. In particular, low-skilled workers are worse off because of the destruction of unskilled jobs (see *Biscourp/Kramarz, 2007*) and the reduction of their wages (see *Bazen/Cardebat, 2001*). In a recent study, *OECD (2008)* states that economic inequality raises social fears, which is one of the most important reasons for resistance to international integration. Moreover, *Scheve and Slaughter (2007)* argue that due to the unequal distribution of trade gains, policy-makers could be forced to increase the degree of protectionism, which clearly countervails the gains of trade. Public policy therefore focuses on finding an applicable redistribution scheme that benefits the harmed groups without destroying the gains of trade.

To compensate the losers, there are two policy instruments: Wage subsidies in order to countervail the decrease in the wage rate for low-skilled workers and unemployment benefits (henceforth UB) in order to attenuate the loss of income due to the job destruction. The former however is empirically rarely observed. On the contrary, adjustments of the UB are one of the core issues in the political debate for the redistribution of trade gains. While it will be good news for low-skilled workers, its implications on the macroeconomic level are critical. UB enhance the average wage rate, which reduces firms' labor demand, output and welfare. Thus, compensating the losers comes at a price: the (partially) destruction of trade gains. Moreover, in a general equilibrium, the government must also take into account the implications of the UB' funding. The arising question is then whether a convenient choice of the financial form may avoid, mitigate or even amplify the destruction of the trade gains.

The contribution of this paper is to investigate the impact of three different financing forms of the UB: (i) a wage tax paid by employees, (ii) a payroll tax paid by firms and (iii) a profit tax paid exclusively by exporters. The structure of the funding ensures that these taxes do not incriminate all workers and firms identically but harm on average the winners of trade. Employed workers benefit in terms of their real wages, firms benefit on average because of increasing productivity and exporters benefit by rising market shares. In order to compare the different opportunities, we abstain from mixing these three kinds of taxes but instead analyze their effects separately. To be more precise, we investigate their implications on the composition of firms, (long-term) (un)employment and aggregate output in a positive, comparative static analysis. Furthermore, we analyze the impact of the redistribution schemes on welfare – defined as output per capita. If welfare decreases, trade gains are destroyed, otherwise, trade gains are recovered.

Our model builds on the framework of *de Pinto and Michaelis (2011)* who combine the *Melitz (2003)* model of monopolistic competition and heterogeneous firms with the existence of heterogeneous workers (i.e. workers are different with respect to their abilities; see *Helpman et al., 2010a, b*) and unionized labor markets (see *Layard/Nickell, 1990*). We additionally incorporate a government

sector and introduce the different redistribution systems. Starting point of our analysis is an open economy setting with relatively high trade costs and without the interference of the government. Afterwards, trade will be liberalized via a reduction of the trade cost. Still without the government's intervention, this leads to the unequal distributed trade gains mentioned above. At this point, the government implements the UB as redistribution scheme and chooses one of the three taxes for its funding.

There are three mechanisms driving our results. First, the well-known firm selection effect (henceforth FS) varies the distribution of active firms and thus average productivity of the active firms. Second, the equilibrium (un)employment rate is determined by the interplay between the union's wage setting behavior (i.e. the target real wage) and the firm's price setting schedule (i.e. the feasible real wage; henceforth FRW). Third, a firm-specific interval of abilities prevails. We assume that each firm sets a minimum quality requirement for its workers while each worker chooses a reservation wage, and he or she does not apply for jobs paying less than that. 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 but only employ low-skilled workers.

Our main findings are: First, UB financed by a wage tax enhances the union's target real wage, employment decreases. If the wage rate rises, firms can however attract relatively more high-skilled workers. The average ability of the firms' employees rises and thus firms' productivity, causing c.p. an increase in aggregate output and welfare. This positive effect interacts with the negative influence of the employment reduction, which leads to a hump-shaped welfare reaction. For low values of the UB, the positive average ability effect dominates; for high values of the UB, the employment reduction dominates. However, for any values of the UB, the positive ability effect is strong enough to completely recover the trade gains.

Second, UB financed by a payroll tax increase firms' marginal costs reducing the FRW. Employment immediately declines, which also lowers welfare. If UB exceeds a well-defined threshold, the trade gains will be completely destroyed.

Third, UB financed by a profit tax decrease average net profit, market entry thus becomes less attractive and the number of firms and goods shrinks. This implies, however, an increase in the demand for each variety, revenues of all firms increase and less productive firms can stay in the market and produce; the FS becomes weaker. Consequently, labor demand for low-ability workers increases. From this channel, employment rises, but this effect interacts with the negative implications of the UB and the weaker FS. The latter induces higher marginal costs since the average productivity of active firms declines, the FRW and the employment decrease. If UB is relatively low, employment increases, otherwise it drops. Regarding welfare, the weaker FS compensates all the potential positive effects; welfare declines. However, the threshold for the level of the UB, where the trade gains are destroyed is higher compared to the case of a payroll tax.

In the literature, the investigation of redistribution schemes of trade gains in general has a long history. For instance, *Dixit and Norman* (1986) show in a full employment trade model that commodity taxes compensate the losers and recover the trade gains. If, however, labor market imperfections are considered, this result may no longer hold. *Brecher and Choudhri* (1994) argue that under a binding minimum wage and hence the existence of involuntary unemployment, the compensation of the losers would fully negate the gains of trade. In a similar vein, *Davidson and Matusz* (2006) create a dynamic model with search frictions. Since workers are dislocated in their framework because of trade liberalization, they investigate the effects of different policy interventions, namely wage subsidies, employment subsidies, UB and training subsidies. As a result, welfare reduces in all cases, but using wage subsidies to compensate those workers who bear the adjustment cost and using employment subsidies to compensate those workers who are not able to leave the shrinking sector because of trade liberalization would minimize total welfare losses.

*Davidson et al.* (2007) claim that fully compensation for the losers of trade could even be urgent to guarantee free trade independent of the conservation of trade gains. In the absence of market interventions, liberalization could be blocked. They create a referendum-based model with a continuum of heterogeneous agents. These agents choose between liberalization and protection, choose whether to compensate dislocated workers and choose the compensation instrument. It can be shown that the opportunity to redistribute increases the probability of liberalization independent of the agenda's order. However, in some parameter constellations, the "right" sequencing of decisions is necessary for this outcome. Agents have to commit to the compensating before the liberalization decision, otherwise protection is chosen.

In comparison to our approach, the mentioned studies have at least one shortcoming: they stick to the assumption of homogeneous firms. Thus, all firms are exporters, all firms gain from trade and the empirically relevant export selection effect is missed. In modern trade theory, this gap is filled using a *Melitz* (2003)-type model of heterogeneous firms and monopolistic competition. A common extension of this model is the incorporation of labor market imperfections (see *Helpman/Itskhoki*, 2010; *Helpman et al.*, 2010a, b and *Felbermayr et al.*, 2011 for the implementation of search and matching frictions; see *Egger/Kreickemeier*, 2009a and *Davis/Harrigan*, 2011 for using efficiency wage approaches as well as *de Pinto/Michaelis*, 2011 for the introduction of unionized labor markets).

However, only a few studies implement a redistribution system. *Egger and Kreickemeier* (2009b) extend the *Melitz* (2003) model using a fair-wage effort model and introducing a government sector. The redistribution system consists of an absolute per capita transfer to all individuals and a proportionally profit tax. In this setting, it can be shown that a tax constellation exists that equalizes the income distribution without eliminating the gains of trade completely. In a very similar framework, *Egger and Kreickemeier* (2012) introduce UB financed by proportional income tax. As a result, employment and welfare decreases. *Helpman and Itskhoki* (2010) model search and matching frictions as well as

UB financed by a lump-sum tax. Then, welfare could either increase or decrease where the latter can be observed for the majority of the parameter constellations.

One additional remark: our welfare measure only consists of the aggregate wage income, which equals a constant share of the aggregate output because of the monopolistic competition setting. While this criterion is sufficient for our positive analysis, the welfare function is incomplete if the government normatively aims to find an optimal redistribution system. In particular, the implications for income distribution should be included. As a prominent example for this purpose, *Itskhoki* (2008) derives an optimal redistribution rule resulting from maximizing a specific welfare function with income inequality as its negative argument.

The remainder of the paper is structured as follows. In section two, we present the set-up of the open economy model at the sectoral level, while the general equilibrium is derived in section three. In section four, we discuss the implications of the government's political instruments separately. Section five provides the simulation results of our three market intervention schemes under consideration of the government's budget constraints. Section six concludes.

## 2 Model

### 2.1 Set-up

Our framework builds on the standard monopolistic competition model with heterogeneous firms by *Melitz* (2003) and its extension to trade unions and heterogeneous workers by *de Pinto* and *Michaelis* (2011). We consider an open economy setting with two symmetric countries. The economy consists of two sectors: a final goods 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:

$$Y = M_t^{\frac{1}{1-\sigma}} \left[ \int_{\nu \in V} q(\nu)^{\frac{\sigma-1}{\sigma}} d\nu + \int_{\nu \in V} q_{im}(\nu)^{\frac{\sigma-1}{\sigma}} d\nu \right]^{\frac{\sigma}{\sigma-1}},$$

$$P = M_t^{\frac{1}{\sigma-1}} \left[ \int_{\nu \in V} p(\nu)^{1-\sigma} d\nu + \int_{\nu \in V} p_{im}(\nu)^{1-\sigma} d\nu \right]^{\frac{1}{1-\sigma}},$$

where  $P$  is the corresponding price index.  $V$  denotes the mass of all potentially available goods  $M_t$  and  $\sigma$  represents the elasticity of substitution between any two varieties ( $\sigma > 1$ ). The index *im* denotes import variables and the index  $t$  indicates variables connected with the total market, i.e. the sum of domestic and foreign market activities. Variables without an index refer to the domestic

market only. We suppose  $Y$  to be the numéraire, which allows for the normalization of the price index:  $P \equiv 1$ . The demand for variety  $\nu$  can be derived from the profit maximization of the final goods producers:

$$q_t(\nu) = q(\nu) + q_{im}(\nu) = \frac{Y}{M_t} \left[ (p(\nu))^{-\sigma} + (p_{im}(\nu))^{-\sigma} \right]. \quad (1)$$

In the intermediate goods sector, there is a continuum of ex-ante homogeneous firms. Firms enter the differentiated sector by paying a fixed entry cost  $f_e > 0$  (measured in units of final goods and equal across firms).  $f_e$  can be interpreted as the irreversible investment for research and development all firms have to incur. After paying,  $f_e$  is sunk. In the subsequent *Melitz*-lottery, firms observe their entrepreneurial productivity  $\phi$ , which is Pareto-distributed with  $G_\phi(\phi) = 1 - (\phi_{\min}/\phi)^k$  for  $\phi \geq \phi_{\min} = 1$  and  $k > 1$ .<sup>1</sup> In addition to the entry cost, there are fixed production costs  $f > 0$  and  $f_x > 0$  (measured in units of final goods and equal across firms).  $f$  and  $f_x$  can be interpreted as the costs of forming a distribution and servicing network in the domestic and foreign market, respectively. These types of fixed costs are called beachhead costs (see, for instance, Helpman et al., 2004).

The economy is endowed with an exogenous number of heterogeneous workers  $\bar{L}$ , who differ in their abilities  $a_j$ ,  $j = 1, \dots, \bar{L}$ . Worker abilities are drawn from a Pareto distribution  $G_a(a) = 1 - (a_{\min}/a)^k$  for  $a \geq a_{\min} = 1$  and individuals are assumed to know and maintain their ability levels at any point in time.<sup>2</sup>

Besides firms and workers, there is a government sector. On the expenditure side, the government pays (worker-specific) UB  $B_j$ . On the revenue side, the government targets to harm mainly the winners of the international integration. Since employed workers benefit in terms of their real wages and exporters benefit in terms of their increasing market shares, the government implements two sources of tax incomes: a wage tax  $T_w$  paid by all employed workers  $H$  and a profit tax  $T_\pi$  paid by exporters  $M_x$ . Furthermore, the average productivity of firms rises because of trade liberalization, implying that firms on average benefit. Thus, a payroll tax  $T_{pw}$  paid by all firms  $M$  is introduced by the government. Formally, the revenue side is characterized by:

$$T_w = \sum_j t_w w_j \quad 0 \leq t_w < 1 \quad j = 1, \dots, H, \quad (2)$$

$$T_{pw} = \sum_i t_{pw} w_i h_i \quad 0 \leq t_{pw} < 1 \quad i = 1, \dots, M, \quad (3)$$

<sup>1</sup>Notably, 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 its employed workers.

<sup>2</sup>*Helpman et al.* (2010a, b) introduced this concept in order to allow for worker heterogeneity. However, in their model, abilities are match-specific and independently distributed. Hence, a worker's ability 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".

$$T_\pi = \sum_i I t_\pi \pi_{it} \quad 0 \leq t_\pi < 1 \quad i = 1, \dots, M_x, \quad (4)$$

$$I = \begin{cases} 1 & \text{if } \phi_i \geq \phi_x^* \\ 0 & \text{otherwise} \end{cases},$$

where  $t_w$ ,  $t_{pw}$  and  $t_\pi$  denote the corresponding proportional tax rates. Additionally,  $h_i$  and  $w_i$  represent the number of employees and the wage rate paid by firm  $i$ , respectively. The indicator variable  $I$  in Eq. (4) is equal to one if a firm exports, i.e. the firm's entrepreneurial productivity exceeds the export cut-off productivity  $\phi_x^*$  (see below) and becomes zero otherwise. Notably, we assume that the tax base of the profit tax,  $\pi_t$ , is the exporters' total profit, i.e. the sum of domestic and export profit.

Let us now turn to the firms' production technology. Consider a firm  $i$  with productivity  $\phi_i$ . The production technology is given by:

$$q_i = h_i \phi_i \bar{a}_i, \quad (5)$$

where  $\bar{a}_i$  represents the average ability of employees. A firm does not demand all abilities but sets a minimum quality requirement. This minimum quality requirement is firm-specific, and it increases with entrepreneurial productivity  $\phi$ . For concreteness, we assume:

$$a_i^* = \phi_i^\alpha \quad \text{with} \quad \alpha \geq 0. \quad (6)$$

Eq. (6) represents a firm's technology constraint: firm  $i$  does not employ workers with abilities lower than  $a_i^*$  because its marginal product of labor is zero (or even negative because of complementaries, see *Helpman et al.*, 2010a, b). Parameter  $\alpha$  denotes the sensitivity of  $a_i^*$  with respect to entrepreneurial productivity.<sup>3</sup>

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 wages. 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 the 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 the upper bound of employees' abilities rises with 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 productivity  $\phi_i$  and wage rate  $w_i$ . The average ability of the firm-specific interval is given by (see *de Pinto/Michaelis*, 2011 for the

<sup>3</sup>The minimum quality requirement assumption can be motivated both from an empirical and a theoretical point of view. For a detailed discussion, see *de Pinto and Michaelis* (2011).



derivation):

$$\bar{a}_i = \Gamma_1 \frac{(a_i^*)^{1-k} - (a_{z_i})^{1-k}}{(a_i^*)^{-k} - (a_{z_i})^{-k}} \quad \text{with} \quad \Gamma_1 \equiv \frac{k}{k-1}, \quad (7)$$

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

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  $\phi_i$ . Given  $\phi_i$ , firm  $i$  decides whether to produce or not and additionally whether to export 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 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 monopoly trade union at the firm level. The membership of monopoly 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).

In the fourth stage, the monopoly union  $i$  sets the wage rate  $w_i$ , where the employment decision of the firm in stage five is anticipated. 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 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 observe the minimum ability of a worker at no costs, 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 Labor demand

We begin by discussing stage five, where  $w_i$ ,  $a_{z_i}$ ,  $a_i^*$  and  $\bar{a}_i$  are already determined. The net profits of firm  $i$  are defined by

$$\pi_i^{net} \equiv (1 - It_\pi) (r_i - (1 + t_{pw})h_i w_i - f), \quad (8)$$

where  $r_i$  is real revenue. Each firm faces a constant elasticity demand curve (1). Thus, the firm’s revenue  $r_i = q_i p_i$  is given by

$$r_i = q_i^\kappa (Y/M_t)^{1/\sigma}, \quad \kappa \equiv 1 - \frac{1}{\sigma}, \quad (9)$$

where  $\kappa$  denotes the degree of competitiveness in the market for intermediate goods. The firm maximizes net profits  $\pi_i^{net}$  by setting employment such that the marginal revenue of labor equals marginal costs:  $\partial r_i / \partial h_i = (1 + t_{pw})w_i$ . The optimal level of employment is given by

$$h_i = \left( \frac{\kappa \phi_i^\kappa \bar{a}_i^\kappa}{(1 + t_{pw})w_i} \right)^\sigma \frac{Y}{M_t}. \quad (10)$$

If the wage rate increases, employment falls:  $\partial h_i / \partial w_i < 0$ . In our model, this outcome is, however, not trivial. A wage hike swells the firm-specific interval of abilities,  $\bar{a}_i$  and thus the marginal revenue rise (the labor demand curve becomes steeper). Consequently, there are two effects operating in the opposite direction in response to a wage increase: marginal costs and marginal revenues shift up. The strength of the latter effect can be measured by the wage elasticity of average abilities  $\epsilon_{\bar{a}_i, w_i}$ . As shown by *de Pinto and Michaelis* (2011) in detail,  $\epsilon_{\bar{a}_i, w_i}$  is equal across all firms and (for reasonable parameter settings) smaller than one. Then, the derivation of (10) with respect to  $w_i$  proves that  $\partial h_i / \partial w_i < 0$  holds for  $\epsilon_{\bar{a}_i, w_i} < 1$ . Increasing marginal revenue does not compensate the rising marginal costs, but mitigates the employment reduction. Note that the number of available goods  $M_t$  and aggregate output  $Y$  are exogenous at the sectoral level. The optimal price

$$p_i = \frac{1}{\kappa} \frac{(1 + t_{pw})w_i}{\phi_i \bar{a}_i} \quad (11)$$

is a constant mark-up  $1/\kappa$  over marginal costs. Note that  $p_i$  is independent of the profit tax rate  $t_\pi$ . Every price setting that implies profit maximization before the profit tax remains also optimal after the profit tax as long as the profits are still positive.

To complete our analysis in stage five, we specify the firm's net profit  $\pi_i^{net}$  as a function of the firms' revenue and model parameters only. In doing so, we reformulate the firm's revenue as a function of its optimal price setting:

$$r_i = p_i^{1-\sigma} \frac{Y}{M_t}. \quad (9')$$

Inserting (9') and  $h_i = q_i / (\phi_i \bar{a}_i)$  [see (5)] into (8) yields:

$$\pi_i^{net} = (1 - It_\pi) \left( \frac{r_i}{\sigma} - f \right). \quad (12)$$

### 2.3 Monopoly union and fallback income

In the fourth stage, the monopoly union  $i$  sets 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 monopoly union maximizes the expected utility of the median member  $m_i$  (see *Booth*, 1984), and thus the objective function is given by:

$$EU_{m_i} = \frac{h_i}{n_i} (1 - t_w) w_i + \left(1 - \frac{h_i}{n_i}\right) b_{m_i}, \quad (13)$$

with  $b_{m_i}$  denoting the reservation wage (fallback income) of the median member and  $(1 - t_w) w_i$  representing the net wage rate. Note that membership  $n_i$  exceeds the firm's labor demand  $h_i$  because of the game structure at stage three (see below). Furthermore, the monopoly unions are risk-neutral by assumption.

The monopoly union  $i$  fixes  $w_i$  to maximize the Nash product  $NP_i = EU_{m_i} - \bar{U}_{m_i}$  subject to  $\partial r_i / \partial h_i = (1 + t_{pw}) w_i$  with  $\bar{U}_{m_i} = b_{m_i}$  being the union's fallback position. Owing to the constraint, the union anticipates that the firm chooses a point on its labor demand curve for any given  $w_i$ .<sup>4</sup> The solution of the optimization problem leads to a well-known result: the wage  $w_i$  is a mark-up  $\theta / (1 - t_w)$  over the median member's fallback income:

$$w_i = \frac{\theta}{1 - t_w} b_{m_i} \quad \text{with} \quad \theta \equiv \frac{1}{\kappa} > 1. \quad (14)$$

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 rate  $w_i$  is increasing in the wage tax  $t_w$ , reflecting the unions' aim to stabilize the workers' net wages.

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:

$$\begin{aligned} V_j &= \frac{1}{1 + \rho} \left[ (1 - t_w) \bar{w}_j + (1 - \delta) V_j + \delta V_j^u \right], \\ V_j^u &= \frac{1}{1 + \rho} \left[ B_j + e_j V_j + (1 - e_j) V_j^u \right], \end{aligned}$$

where  $(1 - t_1) \bar{w}_j$  is worker  $j$ 's net outside wage,  $\rho$  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  $e_j$ . 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  $b_j = \frac{\rho + \delta}{\rho + \delta + e_j} B_j + \frac{e_j}{\rho + \delta + e_j} (1 - t_w) \bar{w}_j$ .

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:

$$\delta (1 - u_j) = e_j u_j. \quad (15)$$

<sup>4</sup>Recall that the labor demand curve becomes steeper if the wage rate increases because of rising average abilities. Consequently, the monopoly union also anticipates the positive effect of a higher wage rate, but as shown above, nevertheless employment decreases.

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

$$u = u_j = 1 - \frac{H_j}{L_j} \quad \forall j. \quad (16)$$

Using (15) and (16), the fallback income can be derived as<sup>5</sup>

$$b_j = uB_j + (1 - u)(1 - t_w)\bar{w}_j. \quad (17)$$

As mentioned, the fallback income of worker  $j$  corresponds with the reservation wage of worker  $j$ . The reservation wage is increasing in the UB,  $B_j$ , and increasing in the outside wage  $\bar{w}_j$ , 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; 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:

$$\bar{w}_j = (a_j)^\omega \left( w(\tilde{\phi}) \right)^{1-\omega} \quad 0 \leq \omega \leq 1. \quad (18)$$

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,  $w(\tilde{\phi})$ , where  $\tilde{\phi}$  denotes the entrepreneurial productivity of the representative firm (see below).<sup>6</sup>

<sup>5</sup>Note that (17) is an approximation, which holds for  $\rho u = 0$ . For a justification of this simplifying assumption, see *Layard and Nickell (1990)*.

<sup>6</sup>One might argue that high-skilled workers with a reservation wage above the wage paid by the representative firm are not affected by  $w(\tilde{\phi})$ . Consequently,  $w(\tilde{\phi})$  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  $\tilde{\phi}$ . Therefore,  $w(\tilde{\phi})$  is only a shortcut for the "true" distribution of wages in the economy. A shift in  $w(\tilde{\phi})$  should thus be interpreted as proxy for a shift in the whole wage distribution, thus affecting all wages irrespective of skill level.

The UB is modelled as a constant share of worker  $j$ 's net outside wage:

$$B_j = s(1 - t_w)\bar{w}_j, \quad (19)$$

with  $0 \leq s \leq 1$  denoting the replacement ratio that is set by the government. Eq. (19) fits two important properties concerning the design of the UB. First,  $B_j$  is worker-specific. High-skilled workers (computer scientists) exhibit a higher outside wage and thus receive a higher benefit relative to low-skilled workers (collectors). Thus, the UB depends on the workers' employment history. Second,  $B_j$  is a positive function of the country's macroeconomic performance, reflecting the connection between government's expenditures and the business cycle (for a similar modelling approach, see *Haan/Prowse, 2010* and for empirical evidence, see *Fitzenberger/Wilke, 2010*).

With these building blocks in place, noting  $j = m_i$ , the fallback income (17) and the bargained wage (14) can be rewritten as

$$b_{m_i} = (1 - t_w)(1 - u(1 - s))(a_{m_i})^\omega \left(w(\tilde{\phi})\right)^{1-\omega}, \quad (20)$$

$$w_i = \theta(1 - u(1 - s))(a_{m_i})^\omega \left(w(\tilde{\phi})\right)^{1-\omega}, \quad (21)$$

respectively. As a first result, for any given level of  $a_{m_i}$ ,  $w_i$  is independent of the wage tax rate  $t_w$ . On the one hand, an increasing  $t_w$  leads to a rise in the union's wage claim [see (14)], which leaves the worker's net wage unchanged. On the other hand, the rising  $t_w$  implies a reduction in the UB and the net outside wage  $(1 - t_1)\bar{w}_j$  of the same magnitude and consequently the fallback income declines [see (20)]. The decrease in  $b_{m_i}$  countervails the increasing wage claim, leaving the bargained wage rate unaffected from variations of  $t_w$ . Notably, this finding strongly depends on the assumption of using the net outside wage in the computation of the UB [see (19)]. If instead  $B_j = s\bar{w}_j$  is applied, the decline in fallback income becomes smaller and thus it does not compensate the increasing wage claim –  $w_i$  would be a positive function of  $t_w$ . However, simulations show that a variation in the wage tax rate has an extremely low influence on  $w_i$  for any given level of  $a_{m_i}$ . Thus, we ignore this effect in the following by using (19) exclusively.<sup>7</sup>

Note that 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.

<sup>7</sup>The corresponding simulation results are available upon request.

## 2.4 Unions' 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 larger than  $a_{z_i}$  have a reservation wage exceeding  $w_i$ , they do not apply and they are not members of monopoly union  $i$ . The number of applicants and thus the number of union members is given by

$$n_i = \int_{a_i^*}^{a_{z_i}} k a^{-(1+k)} da = (a_i^*)^{-k} - (a_{z_i})^{-k}. \quad (22)$$

As shown by *de Pinto* and *Michaelis* (2011), the ability level of the median member can be derived as:

$$a_{m_i} = 2^{1/k} \left[ (a_{z_i})^{-k} + (a_i^*)^{-k} \right]^{-1/k}. \quad (23)$$

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, by contrast, is determined by the requirement that the posted wage equals the reservation wage of the efficient worker  $z_i$ . The upper limit is thus given by (see Appendix A):

$$a_{z_i} = A^{1/k} \phi_i^\alpha \quad A(t_w) \equiv 2 \left( \frac{\theta}{1 - t_w} \right)^{k/\omega} - 1, \quad (24)$$

with  $\partial A / \partial t_w > 0$ . If a firm knows its entrepreneurial productivity  $\phi_i$ , it sets a minimum ability according to (6) and the ability of the efficient worker is given by (24). Inserting both into (23) and observing (21), we can rewrite the wage rate as:

$$w_i = K (1 - u(1 - s)) \left( w(\tilde{\phi}) \right)^{1-\omega} \phi_i^{\alpha\omega} \quad K(t_w) \equiv \theta \left( \frac{2A}{A+1} \right)^{\omega/k}, \quad (25)$$

with  $\partial w_i / \partial t_w > 0$ .

In contrast to (21), the wage depends now positively on  $t_w$ . As mentioned above,  $w_i$  does not vary with  $t_w$  only if  $a_{m_i}$  is constant. However, the derived decline in fallback income because of an increase in  $t_w$  [see (20)] does not only counteract the enhanced wage claim, but also influences the firm-specific interval of abilities. As fallback income shrinks simultaneously for every worker, the firm can attract relatively more high-skilled workers for any given wage offer; the upper limit of abilities  $a_{z_i}$  thus rises [see (24)]. This causes an upside shift of the union's median member  $a_{m_i}$  [see (23)] and consequently  $b_{m_i}$  – the relevant

fallback income for the monopoly union – increases [see (20)]. As a result, the monopoly union sets a higher wage rate if the government increases  $t_w$ .<sup>8</sup>

In stage one, firm  $i$  participates in the *Melitz* lottery and draws the entrepreneurial productivity  $\phi_i$ . Subsequently, the firm has to decide whether to enter the domestic market and to produce or not as well as whether to serve the foreign market and to export or not. A firm will produce for the domestic market if and only if the drawn entrepreneurial productivity is at least as high as the cut-off productivity level  $\phi^*$ :  $\phi_i \geq \phi^*$ . In this case, the expected stream of profits is non-negative. The firm with the lowest possible productivity  $\phi^*$  is called the marginal firm.

Concerning the export decision, there are variable iceberg costs  $\tau > 1$  besides the already mentioned beachhead cost  $f_x \geq 0$ . We can derive an export cut-off level  $\phi_x^*$  such that for  $\phi_i \geq \phi_x^*$  the additional revenue of exporting is at least as high as the additional trade costs.<sup>9</sup> In line with *Melitz* (2003), only a fraction of firms engage in exporting.<sup>10</sup> For  $\phi_i \geq \phi_x^*$ , firms are exporters and produce for both the home and foreign markets. For  $\phi^* \leq \phi_i < \phi_x^*$ , firms produce for the home market only.

If firm  $i$  draws a productivity that exceeds the export cut-off level,  $\phi_i \geq \phi_x^*$ , the derivation of the corresponding export values is needed. As shown by *Melitz* (2003), the export variables can be expressed as a function of the domestic variables:  $p_{ix} = \tau p_i$ ,  $q_{ix} = \tau^{-\sigma} q_i$ ,  $h_{ix} = \tau^{1-\sigma} h_i$  and  $r_{ix} = \tau^{1-\sigma} r_i$ . For the net export profit  $\pi_{ix}^{net}$ , we then obtain:

$$\pi_{ix}^{net} = (1 - t_\pi) \left( \tau^{1-\sigma} \frac{r_i}{\sigma} - f \right), \quad (26)$$

where we make use of the simplifying assumption of  $f = f_x$  (see *Egger and Kreickemeier*, 2009a for a justification). Inserting (12) and (26) into  $\pi_{it}^{net} = \pi_i^{net} + \pi_{ix}^{net}$  yields the total net profit of the exporting firm  $i$ :

$$\pi_{it}^{net} = (1 - I t_\pi) \left( (1 + \tau^{1-\sigma}) \frac{r_i}{\sigma} - 2f \right) \quad \text{with } I = 1. \quad (27)$$

To complete our model at the sectoral level, one crucial step is left. The existence of the 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

<sup>8</sup>A further result: The wage  $w_i$  is increasing in the entrepreneurial productivity  $\phi_i$ . 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).

<sup>9</sup>We provide the analytical evidence for this in section 3.2.

<sup>10</sup>This result is connected with the validity of the partitioning condition. We will come back to this issue in section 3.1.

demand qualifications below  $a^*$ . With (6), we obtain:

$$a^* = (\phi^*)^\alpha. \quad (28)$$

Thus, we divide the labor force  $\bar{L}$  into two groups: (i) active<sup>11</sup> 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, the monopoly union only accounts for active workers in the wage-setting process.

### 3 General equilibrium

So far, we have described the model at the sectoral level. To gain insights into the labor market and good market effects of the government's behavior in the presence of monopoly unions and an open economy setting, we now derive the general equilibrium.

#### 3.1 Average productivity and aggregation

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

$$\tilde{\phi}_t = \tilde{\phi} \left[ \frac{1}{1 + \chi} \left( 1 + \chi \tau^{1-\sigma} \left( \frac{\tilde{\phi}_x}{\tilde{\phi}} \right)^\beta \right) \right]^{1/\beta}, \quad (29)$$

with  $\beta \equiv (\sigma - 1)(1 + \alpha - \alpha\omega) > 0$ .  $\chi$  denotes the ex ante probability of being an exporter:

$$\chi = \frac{1 - G_\phi(\phi_x^*)}{1 - G_\phi(\phi^*)} = \left( \frac{\phi_x^*}{\phi^*} \right)^k, \quad 0 < \chi < 1. \quad (30)$$

$\tilde{\phi}$  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:

$$\tilde{\phi} = \left[ \frac{k}{k - \beta} \right]^{1/\beta} \phi^*, \quad (31)$$

$$\tilde{\phi}_x = \left[ \frac{k}{k - \beta} \right]^{1/\beta} \phi_x^*, \quad (32)$$

with  $k > \beta$  by assumption.

The inspection of (30), (31) and (32) indicates that the total average productivity  $\tilde{\phi}_t$  depends on the relation between the export cut-off level  $\phi_x^*$  and the

<sup>11</sup>"Active" means that these workers have a positive employment probability. Nevertheless, at each point in time a fraction of "active" workers is unemployed.



cut-off productivity level  $\phi^*$ . To calculate  $\phi_x^*/\phi^*$  (and hence  $\tilde{\phi}_x/\tilde{\phi}$ ), we use the well-known zero cut-off profit condition (henceforth ZPC) (see *Melitz*, 2003). By definition, the marginal firm  $\phi^*$  gains a zero net profit:  $\pi_t^{net}(\phi^*) = 0$ . From (27) and  $I = 0$ ,<sup>12</sup> we obtain:

$$r(\phi^*) = \sigma f. \quad (33)$$

Analogically, we define  $\pi_x^{net}(\phi_x^*) = 0$ , where a firm just breaks even in the export market. This condition holds if and only if the exporting revenue covers the extra trading costs:  $r_x(\phi_x^*) = \sigma(f + T_\pi(\phi_x^*))$ . We have already mentioned the first summand in the bracket of the right-hand side, i.e. the foreign beachhead cost. The second summand,  $T_\pi(\phi_x^*)$ , represents the paid profit tax. As mentioned above, the tax base is the total profit of an exporter,  $\pi_t(\phi_x^*) = \pi(\phi_x^*) + \pi_x(\phi_x^*)$  [see (4)]. But since  $\pi_x(\phi_x^*)$  is zero by construction, we can dispose (12) to get  $T_\pi(\phi_x^*) = t_\pi \left( \frac{r(\phi_x^*)}{\sigma} - f \right)$ . Using  $r_x(\phi_x^*) = \tau^{1-\sigma} r(\phi_x^*)$  yields:

$$r(\phi_x^*) = \sigma f \Omega \quad \text{with} \quad \Omega \equiv \frac{1 - t_\pi}{\tau^{1-\sigma} - t_\pi} > 1, \quad (34)$$

where  $\Omega$  represents the additional variable cost connected with exporting.<sup>13</sup>

Inserting (33) and (34) into  $r(\phi_x^*)/r(\phi^*) = (\phi_x^*/\phi^*)^\beta$ , which follows from transformations of (9') and using (31) as well as (32) leads to

$$\left( \frac{\tilde{\phi}_x}{\tilde{\phi}} \right)^\beta = \left( \frac{\phi_x^*}{\phi^*} \right)^\beta = \Omega. \quad (35)$$

Next, we combine (30) with (35) to get  $\chi = \Omega^{-k/\beta}$ . Substituting this result and (35) into (29), we finally obtain:

$$\tilde{\phi}_t = \tilde{\phi} D \quad \text{with} \quad D \equiv \left( \frac{1 + \tau^{1-\sigma} \Omega^{1-k/\beta}}{1 + \Omega^{-k/\beta}} \right)^{1/\beta} > 1. \quad (36)$$

The difference between the two averages  $\tilde{\phi}_t$  and  $\tilde{\phi}$  can be explained by the interplay between the lost-in-transit effect (henceforth LT), i.e. goods vanish en route because of iceberg transport costs and the export-selection effect (henceforth ES), i.e. exporting firms are the most productive in the economy. The LT and ES are measured by  $\tau^{\sigma-1}$  and  $(\phi_x^*/\phi^*)^\beta$ , respectively. The former shrinks total average productivity, the latter increases the total average productivity, both in comparison to the domestic level  $\tilde{\phi}$ . Clearly, the LT always occurs if trade is admitted ( $\tau > 1$  by assumption). If, however, all firms export ( $\phi^* = \phi_x^*$ ), there is no ES and  $\tilde{\phi}_t$  decreases relative to  $\tilde{\phi}$ . In the *Melitz* world, it is typically assumed that the partitioning condition holds, which implies  $\phi^* < \phi_x^*$ . Only the

<sup>12</sup>Notably, (30) implies  $\phi^* < \phi_x^*$ . Thus, the marginal firm only produces for the domestic market, concluding  $I = 0$ .

<sup>13</sup>Note that we parametrically rule out the constellation  $t_\pi > \tau^{1-\sigma}$ , which would lead to a situation where because of extremely high profit tax no firm, independent of their entrepreneurial productivity, has an incentive to export.

most productive firms serve the foreign market and thus the ES is strictly positive. *Egger and Kreickemeier (2009a)* show additionally that if the partitioning condition is fulfilled and no profit tax is implemented ( $t_\pi = 0$ ), the LT and ES always exactly offset each other ( $(\phi_x^*/\phi^*)^\beta = \tau^{\sigma-1}$ ), which implies  $\tilde{\phi}_t = \tilde{\phi}$ .

In our framework, with  $f = f_x$  and  $t_\pi > 0$ , the partitioning condition  $\Omega > 1$  is fulfilled and the ES is thus positive. The inspection of (35) shows however that c.p. the export productivity cut-off increases in  $t_\pi$ , meaning that exporters are even more productive than in the case of  $t_\pi = 0$ . The additional export selection raises the ES above the level that is necessary to countervail the LT, which implies an increase in total average productivity  $\tilde{\phi}_t$ . This mechanism is represented by the parameter  $D$  in Eq. (36). As a result, we obtain  $\tilde{\phi}_t > \tilde{\phi}$  if  $t_\pi > 0$  ( $D > 1$ ) and  $\tilde{\phi}_t = \tilde{\phi}$  if  $t_\pi = 0$  ( $D = 1$ ).

The aggregate variables, which 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  $\Pi^{net} = M_t \pi^{net}(\tilde{\phi}_t)$ . For the employment level, we get:

$$H = h(\tilde{\phi}_t) \xi_1 \xi_2 \psi_1, \quad (37)$$

$$\xi_1 \equiv \left[ \frac{k}{k - \beta} \right]^{\alpha\omega/\beta}, \quad \xi_2 \equiv \frac{k - \beta}{k - \beta + \alpha\omega}, \quad \psi_1 \equiv M + M_x \left( \frac{\phi^*}{\phi_x^*} \right)^{\alpha\omega}.$$

Recall that  $M_x$  represents the number of exporters and  $M$  denotes the number of firms located in each country. The total number of all active firms (and thus the number of all available varieties) in a country is given by  $M_t = M + M_x = M(1 + \chi)$ .

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  $u$ . 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

$$\bar{u} = 1 - (a^*)^{-k} \frac{H}{L}. \quad (38)$$

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  $M_t$  identical firms with productivity  $\tilde{\phi}_t$ . Therefore, we treat the firm with productivity  $\tilde{\phi}_t$  as the representative firm of the economy.

### 3.2 Firm entry and exit

We now turn to the analysis of firm entries and exits, which ends up in the determination of the cut-off productivity  $\phi^*$ . In line with *Melitz* (2003), two conditions must hold in the case of production: the free-entry condition (henceforth FE) and ZPC.

We have already introduced the ZPC and obtained (33). In a next step, we derive the average net profit per firm  $\bar{\pi}_t^{net} \equiv \Pi^{net}/M$  that exists in the economy if the marginal firm gains zero profit. Using  $\Pi^{net} = M_t \pi^{net}(\tilde{\phi}_t)$ ,  $M_t = M(1 + \chi)$  and (12), we get  $\bar{\pi}_t^{net} = (1 + \chi) \left[ (1 - t_\pi) \left( \frac{r(\tilde{\phi}_t)}{\sigma} - f \right) \right]$ . Substituting consecutively  $r(\tilde{\phi}_t) = (\tilde{\phi}_t/\phi^*)^\beta r(\phi^*)$  and (33) yields:

$$\bar{\pi}_t^{net} = (1 + \chi) (1 - t_\pi) f \left( \left( \frac{\tilde{\phi}_t}{\phi^*} \right)^\beta - 1 \right).$$

Finally, using (31) and (36) leads to the average net profit in the presence of the ZPC:

$$\bar{\pi}_t^{net} = (1 + \chi(t_\pi)) (1 - t_\pi) f \left( \frac{k((D(t_\pi))^\beta - 1) + \beta}{k - \beta} \right), \quad (39)$$

with  $\chi(t_\pi) = \Omega^{-k/\beta}$ . As a result, the average net profit in the economy is independent of  $\phi^*$ , which is a direct consequence of the Pareto distribution properties.

The FE ensures that all existing firms have an incentive to participate in the *Melitz* lottery. Formally, this requires  $f_e = (1 - G_\phi(\phi^*)) \bar{\pi}_t^{net} / \delta$ , with  $1 - G_\phi(\phi^*)$  denoting the probability of a successful draw. Hence, in the equilibrium, the sunk cost component is equal to the expected discounted average net profits. Using the Pareto-distribution, we obtain:

$$\bar{\pi}_t^{net} = (\phi^*)^k \delta f_e. \quad (40)$$

With (39) and (40) at hand, we compute the cut-off productivity level:

$$\phi^* = \left[ (1 + \chi(t_\pi)) (1 - t_\pi) f \left( \frac{k((D(t_\pi))^\beta - 1) + \beta}{(k - \beta)\delta f_e} \right) \right]^{1/k}. \quad (41)$$

Thus,  $\phi^*$ ,  $\tilde{\phi}$  and  $\tilde{\phi}_t$  depend on the profit tax rate  $t_\pi$ . Note that any increase in  $\phi^*$  induces the FS – e.g. the least productive firms are driven out of the market and average productivity rises – as explained in detail by *Melitz* (2003). However, variations of  $\phi^*$  have a further consequence in our setting. If, e.g.,  $\phi^*$  increases, the ability cut-off goes up as well [see (28)], implying that the labor demand for workers with abilities below (the raised)  $a^*$  decrease to zero – workers with  $a < a^*$  do not fulfill any job requirement in the economy. Consequently, they are driven out of the labor market and switch to long-term unemployment. We call this channel worker selection effect in the following (see *de Pinto/Michaelis*, 2011 for a detailed discussion).

### 3.3 Equilibrium (long-term) unemployment and welfare

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  $p(\tilde{\phi}_t) = 1$ . Then, the price rule (11) delivers the FRW:

$$w_{PS}(\tilde{\phi}_t) = \frac{1}{1 + t_{pw}} \kappa \bar{a}(\tilde{\phi}_t(t_\pi), t_w) \cdot \tilde{\phi}_t(t_\pi). \quad (42)$$

The FRW is independent of (un)employment, which is no surprise because of our assumptions about technology (output is linear to labor) and the constant price elasticity of product demand. As a specification of our model, the FRW depends positively on the average ability level. Inserting the minimum quality requirement (6), the upper bound of abilities (24) and  $\phi_i = \tilde{\phi}_t$  into the average ability (7) yields:

$$\bar{a} = \Gamma_1 \Gamma_2(t_w) \cdot \left( \tilde{\phi}_t(t_\pi) \right)^\alpha, \quad \Gamma_2(t_w) \equiv \frac{A - A^{1/k}}{A - 1}. \quad (43)$$

Since a higher wage tax raises the wage rate as explored above, the firm-specific interval of abilities expands and average abilities increases:  $\partial \bar{a} / \partial t_w > 0$ . This translates into a rise in marginal revenue – the FRW shifts up:  $\partial w_{PS} / \partial t_w > 0$ . On the contrary, an increase in the payroll tax rate leads to a rise in firms' marginal costs, which implies a reduction in the FRW:  $\partial w_{PS} / \partial t_{pw} < 0$ . Finally, the implications of the profit tax rate  $t_\pi$  are ambiguous as shown in more detail below.

Let us turn to the target real wage. The (representative) monopoly union fixes the wage rate; we obtain (25). Taking the macroeconomic variables as given, the target real wage of the (representative) monopoly union can be written as

$$w_{WS}(\tilde{\phi}_t) = K(t_w) \cdot \left( w(\tilde{\phi}_t) \right)^{1-\omega} (1 - u(1 - s)) \cdot \tilde{\phi}_t(t_\pi)^{\alpha\omega}. \quad (44)$$

with  $\partial w_{WS} / \partial t_w > 0$  and ambiguous consequences from variation of  $t_\pi$ .

In the general equilibrium, we have  $w_{PS}(\tilde{\phi}) = w_{WS}(\tilde{\phi}) = w(\tilde{\phi})$ . By combining (42) and (44), we can calculate the number of long-term unemployed  $L^l$ , the number of active workers  $L$ , the number of employed active workers  $H$ , the aggregated unemployment rate  $\bar{u}$ , the measure of welfare  $Y/\bar{L}$  and the number of firms  $M$  for any given parameter setting of the government (see Appendix B).

The general equilibrium is thus given by:<sup>14</sup>

<sup>14</sup>The stability of the general equilibrium turns out to be critical in one way. Theoretically, the marginal firm has an incentive to deviate from the (monopoly union) wage setting in order to increase its profit. As explored in detail by *de Pinto* and *Michaelis* (2011), however, we can avert this behavior by assuming a further labor market friction, i.e. efficiency wages. Clearly, extending the model in that way has a value added. But balancing this value added with the loss of analytical tractability we decided to postpone this issue to further research and refrain from giving marginal firms additional latitude.

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

$$L = \xi_3 D(t_\pi)^{\alpha k} \cdot \left(\tilde{\phi}_t(t_\pi)\right)^{-\alpha k} \cdot \bar{L}, \quad (46)$$

$$H = \frac{\Gamma_3(t_w, t_{pw}) \cdot \left(\tilde{\phi}_t(t_\pi)\right)^\omega - s}{1 - s} \xi_3 D(t_\pi)^{\alpha k} \cdot \left(\tilde{\phi}_t(t_\pi)\right)^{-\alpha k} \cdot \bar{L}, \quad (47)$$

$$\bar{u} = 1 - \frac{\Gamma_3(t_w, t_{pw}) \cdot \left(\tilde{\phi}_t(t_\pi)\right)^\omega - s}{1 - s} \xi_3 D(t_\pi)^{\alpha k} \cdot \left(\tilde{\phi}_t(t_\pi)\right)^{-\alpha k}, \quad (48)$$

$$\frac{Y}{\bar{L}} = \frac{\Gamma_3(t_w, t_{pw}) \cdot \left(\tilde{\phi}_t(t_\pi)\right)^\omega - s}{1 - s} \cdot \frac{\Gamma_2(t_w) \cdot D(t_\pi)^{\alpha k} \left(\tilde{\phi}_t(t_\pi)\right)^{1+\alpha-\alpha k}}{(\psi_2(t_\pi) \xi_3 \Gamma_1)^{-1} \xi_1 \xi_2}, \quad (49)$$

$$M = \frac{Y(s, t_w, t_{pw}, t_\pi)}{\left(1 + (\Omega(t_\pi))^{-k/\beta}\right) \xi_4 D(t_\pi)^\beta}. \quad (50)$$

The used definitions are:

$$\begin{aligned} \Gamma_3(t_w, t_{pw}) &\equiv \frac{1}{A_0(t_w)} \left(\frac{\kappa \Gamma_1 \Gamma_2(t_w)}{1 + t_{pw}}\right)^\omega, \\ \xi_3 &\equiv \left(\frac{k}{k - \beta}\right)^{\alpha k/\beta}, \quad \xi_4 \equiv \frac{fk\sigma}{k - \beta}, \quad \psi_2(t_\pi) \equiv \frac{1 + \chi(t_\pi)}{1 + \chi(t_\pi)^{(\alpha\omega+k)/k}} > 1. \end{aligned}$$

## 4 The government's policy instruments: partial analysis

Given the derived general equilibrium, we now investigate the impact of the government's policy instruments on the model's outcomes in more detail. We begin with a partial analysis, i.e. discussing the effects of *introducing* UB and its three kinds of funding separately.<sup>15</sup> We regard just one of the government's political parameters at a time, setting the others equal to zero.<sup>16</sup> To be more precise, we subsequently analyze the influence of the government's decisions on the distribution of firms operating in the market (namely the FS), on the labor and the goods market outcomes as well as on welfare.

<sup>15</sup>This scenario is clearly unrealistic since in almost all countries UB and the corresponding taxes already exist. To hold our analysis tractable at this stage, we use  $ds = s$  as a shortcut for  $ds > 0$  and also follow this rule for the revenue side. With a similar justification, the comparison between a closed and an open economy can be found in the literature as a shortcut for trade liberalization.

<sup>16</sup>Analytically, it is also possible that the remaining policy instruments are constant, but different from zero. Since this proceeding does not create new insights or effects, but only complicates the equations, we abstain from it.

## 4.1 Unemployment benefits

Consider first the introduction of UB with the replacement ratio  $s$  ( $ds = s$  and  $t_w = t_{pw} = t_\pi = 0$ ) as the political variable. As shown by (39) and (40), the ZPC and FE are both unaffected, leaving cut-off productivity  $\phi^*$  and total average productivity  $\tilde{\phi}_t$  unchanged. Thus, the FS is independent of the replacement ratio  $s$ , the distribution of active firms remains constant. Since the replacement ratio has no effect on  $\phi^*$ , the ability cut-off  $a^*$  remains constant as well, implying that the segregation of the labor force and thus the number of long-term unemployed persons  $L^l$  do not vary with  $s$  [see (45)].

But the employment of active workers is affected. Let us label a situation without the government by an apostrophe, then from (47) we get  $H/H' < 1$ .<sup>17</sup> The UB raises the fallback income of the union's median member, which implies an increase in the union's target real wage at any given level of employment [see (44)]. The firm's answer to such a rise in its marginal costs is an increase in its profit-maximizing price. Product and labor demand drop, and the number of employed active workers  $H$  decreases. Owing to the constant  $L^l$ , the decrease in the labor demand of active workers causes an increase in the aggregated unemployment rate  $\bar{u}/\bar{u}' > 1$  [see (48)].

The decline in  $H$  leads to a reduction in the overall firm's production; the aggregated output  $Y$  shrinks. Thus, the country's welfare decreases:  $(Y/\bar{L})/(Y'/\bar{L}) < 1$  [see (49)].

## 4.2 The wage tax

Turning to the impact of introducing the wage tax with  $dt_w = t_w$  and  $s = t_{pw} = t_\pi = 0$ , we again find no effect on the FS –  $\phi^*$  and  $\tilde{\phi}_t$  are independent of  $t_w$ . As a consequence,  $a^*$  and thus  $L^l$  do not vary.

However, we know that  $t_w$  influences the union's wage claim. Recall that for any given  $a_{m_i}$  the increase in the wage mark-up  $\theta/(1 - t_w)$  and the decrease in worker  $m$ 's fallback income  $b_{m_i}$  exactly offset each other. However, the decline in  $b$  is identical across all workers, and thus the firm can attract relatively more high-skilled workers. The upper bound of the firm-specific interval of abilities  $a_{z_i}$  rises, which in turn leads to an increase in  $a_{m_i}$ . If firm  $i$  is the representative firm,  $\phi_i = \tilde{\phi}_t$ , this channel ends up boosting the union's target real wage at any given level of employment [see (44)]:  $w_{WS}/w'_{WS} = A_0/A'_0 > 1$ . Consequently, the aggregated labor demand drops as mentioned above.

In the general equilibrium, the increase in  $a_z$  has another implication. The extension of the firm-specific interval of abilities boosts the average ability level  $\bar{a}(\tilde{\phi}_t)$ , thereby reducing the firm's marginal costs; the FRW shifts up [see (42) and (43)]:  $w_{PS}/w'_{PS} = \Gamma_2/\Gamma'_2 > 1$ .<sup>18</sup> Owing to the reduction in the marginal

<sup>17</sup>For concreteness, the apostrophe indicates the case of  $s = t_w = t_{wp} = t_\pi = 0$ . The model's outcome is then identically to the results provided by *de Pinto* and *Michaelis* (2011) if  $\gamma = 1$  applies.

<sup>18</sup>At first glance, this result is straightforward at the microeconomic level but seems to be critical from the macroeconomic perspective. Since every firm expands its ability interval,

cost, labor demand increases.

Concerning the net effect, we obtain from (47):

$$\frac{H}{H'} = \frac{\Gamma_3}{\Gamma'_3} = \left(\frac{\Gamma_2}{\Gamma'_2}\right)^\omega \frac{A'_0}{A_0} > 1.$$

Thus, we cannot analytically determine whether the rise in the FRW or the increase in the target real wage dominates; the employment effect of  $dt_w = t_w$  is ambiguous. In the same way, we find no unique relationship between the introduction of the wage tax and the aggregated unemployment rate  $\bar{u}$ .

Concerning welfare, the introduction of  $t_w$  even has an additional effect. From (49), we get:

$$\frac{Y/\bar{L}}{Y'/\bar{L}} = \frac{\Gamma_3}{\Gamma'_3} \cdot \frac{\Gamma_2}{\Gamma'_2} > 1.$$

The first factor is the (ambiguous) employment channel. The second factor results from the rising average ability level  $\bar{a}(\tilde{\phi}_t)$  because of  $dt_w = t_w$ , which improves the marginal product of labor [see (5)]. Since  $Y = M_t q(\tilde{\phi}_t)$  holds in the general equilibrium, output as well as the welfare level directly increases from this channel:  $\Gamma_2/\Gamma'_2 > 1$ . However, we cannot analytically determine the net effect again.

Our partial analysis of the wage tax concludes that its implications are not "crystal clear". Looking at the literature, there are several studies with, not surprisingly from the predictions of our model, different results. For instance, *Layard et al. (1991)* and *Pissarides (1998)* show that the wage tax has no impact on the wage rate and employment, which would be the case in our setting if  $a_m$  remains constant (see above) or if  $H/H' = 1$  holds. More recent empirical studies indicate, however, that increasing wage taxation induces a higher wage rate and thus a higher unemployment rate in the long run (see *Nickell et al., 2005* and *Daveri/Tabellini, 2000*).

### 4.3 The payroll tax

Next, we consider the introduction of the payroll tax with  $dt_{pw} = t_{pw}$  and  $s = t_w = t_\pi = 0$ . Concerning the employment of active workers first,  $dt_{pw} = t_{pw}$  raises the marginal costs of the representative firm. The optimal response is clearly an increase in prices, which leads to a decrease in the FRW,  $w_{PS}/w'_{PS} < 1$  [see (42)]. The rise in prices dampens the demand for each variety, and thus

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the result predicts that a pure shifting of worker abilities implies an increase in the average abilities of the firms' employees. To get an intuition for that, suppose the following example. There are two firms, 1 and 2 with  $\phi_1 > \phi_2$  and a worker  $j$  with a reservation wage  $w_j^*$ . At the starting point, we have  $w_1 > w_j^* > w_2$  and thus only firm 1 is able to employ worker  $j$ . Assume additionally that worker  $j$  is within the high-productive firm 1 a relatively low-ability worker. If for some reasons, e.g. the introducing of the wage tax,  $w_j^*$  declines, then also the relatively low-productive firm 2 can employ worker  $j$  where he or she would be a relatively high-ability worker. Consequently, shifting worker  $j$  from firm 1 to 2 implies an increase in the employer's average abilities in both firms as predicted by our model.

production and employment fall [see (47)]:

$$\frac{H}{H'} = \frac{\Gamma_3}{\Gamma'_3} = (1 + t_{pw})^{-\omega} < 1.$$

The employment reduction leads to a one-to-one decrease in aggregated output and welfare [see (49)]:

$$\frac{Y/\bar{L}}{Y'/\bar{L}} = \frac{\Gamma_3}{\Gamma'_3} = (1 + t_{pw})^{-\omega} < 1.$$

Like the former policy instruments, the FS remains constant. Thus,  $\phi^*$  and  $\tilde{\phi}_t$  are unaffected just as  $a^*$  and the number of long-term unemployed persons. The economic intuition behind this result is as follows. On the one hand, the number of active firms in the market declines,  $M/M' < 1$  [see (50) and  $Y/Y' < 1$ ]. The demand reduction mentioned above yield a decrease in the firms' net profits implying that the least productive firms are driven out of the market. On the other hand, the decreasing number of firms raises the demand for each variety, revenues and profits of the still active firms increase. Given this outcome, a firm that observes  $\phi^*$  in the *Melitz* lottery can still obtain a zero-profit and thus stay at the market.<sup>19</sup>

Note that these findings also hold if the government would introduce a tax on firms' revenues. Due to the mark-up pricing rule, the optimal response of such an increase in marginal costs is a rise in prices. The FRW falls, and thus employment as well as the welfare unambiguously decreases.

#### 4.4 The profit tax

In contrast to previous findings, the introduction of the profit tax,  $dt_\pi = t_\pi$  ( $s = t_w = t_{pw} = 0$ ) has an impact on the FS. Considering the ZPC (39) and using  $\chi = \Omega^{-k/\beta}$ , we obtain:

$$\frac{\bar{\pi}_t^{net}}{(\bar{\pi}_t^{net})'} = (1 - t_\pi) \frac{1 + \Omega(t_\pi)^{-k/\beta} f k (D(t_\pi)^\beta - 1) + f\beta}{1 + \tau^{-(\sigma-1)k/\beta} f\beta}.$$

The profit tax operates through three channels. First,  $dt_\pi = t_\pi$  c.p. reduces average net profits in the economy directly. Second, (30) and (35) show that the probability of being an exporter  $\chi$  declines. Observing  $M_t = (1 + \chi)M$  and  $\Pi^{net} = M_t \pi^{net}(\tilde{\phi}_t)$  shows that the aggregate net profit  $\Pi^{net}$  c.p. decreases and thus so does average net profit per firm  $\bar{\pi}_t^{net}$ :  $(1 + \Omega_2^{-k/\beta}) / (1 + \tau^{-(\sigma-1)k/\beta}) < 1$ . Third, as explained above, the ES exceeds the LT if  $t_\pi > 0$ , which is measured by  $D > 1$ . Consequently, average productivity increases at any given level of

<sup>19</sup>Recall that in every period, a fraction of firms are hit by an exogenous death shock  $\delta$  and leave the market immediately. To ensure the stability of the general equilibrium, those firms have to be replaced with the same number of firms entering the market:  $\delta M = M^e$ . Thus, at any point of time, there are firms that participate in the *Melitz* lottery and potentially observe  $\phi^*$  as its productivity.



$\phi^*$ :  $\tilde{\phi}_t/\tilde{\phi}'_t = D > 1$  [see (36)], inducing an increase in average net profit per firm:  $(fk(D^\beta - 1) + f\beta)/f\beta > 1$ . As a result, channels one and two reduce  $\bar{\pi}_t^{net}$ ; channel three, however, increases  $\bar{\pi}_t^{net}$ . Thus, the profit tax effect on the ZPC and hence on  $\bar{\pi}_t^{net}$  is ambiguous.<sup>20</sup>

Owing to Pareto-distributed entrepreneurial productivities, the ZPC uniquely determines  $\bar{\pi}_t^{net}$ . For simplicity, let us assume that  $\bar{\pi}_t^{net}$  decreases in response to the introduction of  $t_\pi$ , i.e. channels one and two dominate channel three. The consequences for the economy are straightforward. Since  $\bar{\pi}_t^{net}$  declines, the present value of average net profits  $(1 - G(\phi^*))\bar{\pi}_t^{net}/\delta$  decreases for any given level of  $\phi^*$ . Hence, the entry into the *Melitz* lottery is less attractive, which c.p. reduces the mass of firms passing through the lottery successfully. Thus, the number of available goods in the market,  $M_t$ , shrinks, implying c.p. a demand increase for each variety [see (1)]. Consequently, the revenues of all firms shift up whereby less productive firms than before the profit tax can cover their fixed costs and enter the market.<sup>21</sup> Analytically,  $\phi^*$  decreases, which in turn diminishes the FS, implying a decrease in the average productivity of all domestic firms  $\tilde{\phi}$  [see (31)]. Notably, the inverse conclusion holds if  $\bar{\pi}_t^{net}$  increases.

Let us turn to the influences on the labor and goods market. Based on our findings, the variation in  $\bar{\pi}_t^{net}$  and thus the sign of the FS is ambiguous. The distribution of active firms may shift up or down with the corresponding consequences for  $\tilde{\phi}$  [see (31)] and c.p. for  $\tilde{\phi}_t$  [see (36)]. The latter, however, is additionally affected by the ES. The profit tax unambiguously enhances export selection which leads to a rise in total average productivity  $\tilde{\phi}_t$  for any given level of  $\phi^*$ . In order to separate both elements, we divide  $\tilde{\phi}_t$  according to (36) into the FS element  $\tilde{\phi}$  and the ES element  $D$ . Thus, we can distinguish two cases:

- (i) negative FS ( $\phi^*/\phi^{*'} < 1$  and  $\tilde{\phi}/\tilde{\phi}' < 1$ ) and positive ES ( $D > 1$ )

The lower FS changes the segregation of the labor force. Combining (45) and (46) with (36), we get:

$$\frac{L^l}{L^u} = \frac{1 - \xi_3 \cdot \tilde{\phi}^{-\alpha k}}{1 - \xi_3 \cdot (\tilde{\phi}')^{-\alpha k}} < 1 \quad \text{and} \quad \frac{L}{L'} = \left( \frac{\tilde{\phi}}{\tilde{\phi}'} \right)^{-\alpha k} > 1.$$

The decrease in the cut-off productivity leads to a fall in workers' minimum quality requirements, and thus the number of long-term unemployed persons shrinks: the worker selection effect becomes weaker. Concerning the number of employed persons, we observe from (47) and (36):

$$\frac{H}{H'} = \left( \frac{\tilde{\phi}}{\tilde{\phi}'} \right)^{\omega - \alpha k} D^\omega.$$

<sup>20</sup>In the case that all firms must pay the profit tax (not only exporters), the probability of being an exporter,  $\chi$ , and the export cut-off ( $D = 1$ ) remain unchanged. Thus, the profit tax unambiguously decreases  $\bar{\pi}_t^{net}$  (see *Egger/Kreickemeier, 2009b* for a similar result).

<sup>21</sup>In a more technical reasoning, the decline in  $(1 - G(\phi^*))\bar{\pi}_t^{net}/\delta$  injured the FE and thus the existence of a stationary equilibrium (see *Melitz, 2003*). Therefore, the cut-off productivity  $\phi^*$  decreases, raising the probability of getting a favorable draw  $1 - G(\phi^*)$  and thus increasing the present value of  $\bar{\pi}_t^{net}$  until the FE holds again [see (40)].

Weaker worker selection increases employment  $H$ . But there are two additional effects. First, the lower FS and thus the decrease in  $\tilde{\phi}$  enhance the marginal costs of the representative firm, shifting down the FRW and labor demand. The employment of active workers decreases one-to-one.<sup>22</sup> Second, the ES implies a rise in average productivity, reducing marginal costs, which contradicts the FRW effect. For  $0 < \omega < \alpha k$ , the ES and the worker selection effect dominate the FRW effect; labor demand increases. For  $\omega > \alpha k$ , the decrease in the FRW compensates the weaker worker selection, but the extra labor demand because of the ES may countervail this. Hence, the overall employment effect depends on the parameter setting. In the same way, the aggregated unemployment rate  $\bar{u}$  decreases for  $0 < \omega < \alpha k$ , but its variation is ambiguous for  $\omega > \alpha k$  [see (38)]. Concerning the impact on welfare, we can combine (49), and (36) to obtain:

$$\frac{Y/\bar{L}}{Y'/\bar{L}} = \left( \frac{\tilde{\phi}}{\tilde{\phi}'} \right)^{\omega+1+\alpha-\alpha k} D^{\omega+1+\alpha}.$$

The sign of the net effect is again parameter-dependent. We find five channels that partially work in opposite directions. First, the lower worker selection implies c.p. a higher employment level and increases therefore output and welfare. Second, the decrease in the FRW reduces output and welfare with the factor  $\omega$ . Third, owing to the technology assumption (5), the weaker FS (lower  $\tilde{\phi}$ ) directly reduces output one-to-one. Fourth, the decrease in  $\tilde{\phi}$  causes a fall in average abilities of the active workers [see (43)]. This reduces output by the factor  $\alpha$ . Finally, the ES raises the average productivity and thus works in the opposite direction to channels two, three and four; output and welfare consequently increase because of the ES. The implications are straightforward. For  $\omega + 1 + \alpha < \alpha k$ , the positive worker selection effect dominates the negative effects of reducing  $\tilde{\phi}$ ; the ES enforces this outcome. Output and welfare unambiguously rise. For  $\omega + 1 + \alpha > \alpha k$ , however, output and welfare decline due to the interplay between channels one to four. However, the positive acting ES may countervail this. As a result, the output and welfare effect is in this case ambiguous.

(ii) positive FS ( $\phi^*/\phi^{*'} > 1$  and  $\tilde{\phi}/\tilde{\phi}' > 1$ ) and positive ES ( $D > 1$ )

If the cut-off productivity increases, the number of long-term unemployed persons shifts up. Employment, output and welfare decrease. However, the sharper FS (higher  $\tilde{\phi}$ ) generates the opposite outcome: the FRW increases, labor demand, and output as well as welfare rise. Additionally, the ES implies a further increase in total average productivity, thereby reducing firms' marginal

<sup>22</sup>This effect is mitigated by a decrease in the target real wage. According to (6), the representative firm decreases its minimum quality requirement, while the union focuses on a median member with lower abilities than before and bargains for a lower wage. The reduction in the target real wage will be reinforced by the impairment in macroeconomic performance. The outside wage of the median member decreases [see (18)], and because of a lower fallback income the union reduces its wage claim. Consequently, the labor demand increases. However, for  $\omega > 0$ , the net effect is always negative: the decreasing labor demand due to the FRW effect dominates the increasing labor demand due to the union's lower wage claim.

costs, which also has a positive impact on employment and welfare as described in more detail above. Thus, the total effects on employment and welfare are parameter-dependent. For  $\omega > \alpha k$ , the employment effect is strictly positive. For  $\omega < \alpha k$  employment declines because of the dominance of the worker selection effect, but increases due to the positive acting ES; the net effect is thus ambiguous. Similarly, welfare increases for  $\omega + 1 + \alpha > \alpha k$  but its variation is ambiguous for  $\omega + 1 + \alpha < \alpha k$ .

## 5 The redistribution schemes: total analysis

### 5.1 The government's budget constraint

So far, we have treated the government's values  $s$ ,  $t_w$ ,  $t_{pw}$  and  $t_\pi$  as exogenously given. In a general equilibrium, however, the government has to keep to its budget constraint. To calculate this budget constraint, we assume the following procedure. At the starting position, the economy stands in the general equilibrium after trade liberalization, i.e. lowering  $\tau$  (see below), and without government interference ( $s = t_w = t_{pw} = t_\pi = 0$ ). Next, the government introduces UB by setting the replacement ratio  $s$  and chooses *one* of the three types of taxes.<sup>23</sup> The budget constraint then endogenously determines the corresponding tax rates, which lead to an equalized balance. Clearly, the government's policy instruments are not revenue-neutral but they have repercussion effects on the budget. To avoid further complications from this channel, we follow *Creedy* and *McDonald* (1992) as well as *Goerke* (1996) in assuming that the budget is ex ante revenue-neutral, i.e. the budget does not vary in response to the government's policy.<sup>24</sup> Formally, the budget constraint is always computed for the general equilibrium at the starting position and we thus indicate the respective variables with an apostrophe in the following.<sup>25</sup>

Let us first look at the expenditure side. Aggregated UB is given by  $B = B_{active} + B_l$ . The first summand represents the aggregated UB of all active workers. Using (18) and (19), we obtain:

$$B_{active} = s \int_{a^*}^{\infty} a^\omega w' \left( \tilde{\phi}'_t \right)^{1-\omega} \mu'(a) L^{w'} da,$$

with  $L^{w'} = H' - L'$  denoting the number of unemployed active workers and  $\mu'(a) = g_a(a)/(1 - G'_a(a^{*'}))$  representing the distribution of abilities conditional on  $a \geq a^{*'}$ , i.e. the ability distribution of active workers. Next, we calculate  $B_l$ , which denotes UB of long-term unemployed persons  $L^l$  with  $a < a^{*'}$ . Since long-term unemployed persons have no opportunity to get a job in the economy,

<sup>23</sup>Note that we abstain from mixing the three sources of income in order to consider the diverging effects of the differential taxes separately.

<sup>24</sup>For a general equilibrium model with ex post revenue-neutrality, i.e. the budget is neutral after the consideration of all possible adjustments in the economy, see *Michaelis* and *Pflüger* (2000).

<sup>25</sup>Recall that the apostrophe denotes the  $s = t_w = t_{pw} = t_\pi = 0$  case.

their outside wage drops to zero and thus (19) would be zero as well. Therefore, we assume that the UB of  $L^l$  has a slightly different form:  $B_l = sw' \left( \tilde{\phi}_t' \right) L^l$ . Workers with abilities below  $a^{*l}$  get homogeneous UB [ $\omega = 0$  in (19)], which is modelled as a constant share  $s$  of the equilibrium wage rate. Total expenditure is thus given by:

$$B = s \left[ w' \left( \tilde{\phi}_t' \right) L^l + \frac{k}{k - \omega} (a^{*l})^\omega w' \left( \tilde{\phi}_t' \right)^{1 - \omega} L^w \right]. \quad (51)$$

In order to determine the budget constraint, we calculate total tax revenue (see Appendix C). Since the government chooses only one of the three types of taxes, we distinguish between three possible redistribution schemes with three separate budget constraints.

*Redistribution scheme 1: UB and the wage tax*

$$B^{aggr.} = T_w^{aggr.} = t_w \kappa Y'. \quad (52)$$

*Redistribution scheme 2: UB and the payroll tax:*

$$B^{aggr.} = T_{pw}^{aggr.} = t_{pw} \kappa Y'. \quad (53)$$

*Redistribution scheme 3: UB and the profit tax:*

$$B^{aggr.} = T_\pi^{aggr.} = t_2 \chi' M' \left( (1 + \tau^{\sigma-1}) r' (\tilde{\phi}_t') / \sigma - 2f \right). \quad (54)$$

## 5.2 Calibration

Now, we analyze the impact of the government's decisions under consideration of these budget constraints. Analytically, we solve the budget constraints respectively for  $t_w$ ,  $t_{pw}$ , as well as  $t_\pi$ , and insert the results into the outcome of the general equilibrium. For the three market interventions, we obtain a system of equations that only depends on the replacement ratio  $s$  and on model parameters. Hence, the government's choice of the replacement ratio's size and their funding pins down the labor and goods market values.

Although we are able to provide a closed form solution in this way, the government's influences are potentially ambiguous. Our findings in the partial analysis already indicate that the net effect of the taxation system is undetermined in most cases. Under the consideration of both, namely the replacement ratio  $s$  and the financial form, this tendency is even more likely. In order to obtain explicit results, we thus simulate our model. The following numerical illustration is based on standard practice in the literature. Table 1 summarizes the parameter values for monthly time periods.

We follow *Ghironi and Melitz (2005)* as well as *Felbermayr et al. (2011)* to calibrate most of the *Melitz* model elements, but we make one substantial variation. As stated by *Eaton et al. (2004)*, we set the shape parameter of the Pareto distribution to be equal to 4.2, which is relatively higher in comparison to its standard calibration value of 3.4. This variation can be justified by the

Parameter	Value	Interpretation	Source
$\tau_0, \tau_1$	1.6, 1.3	Iceberg trade cost	Ghironi/Melitz (2005)
$\sigma$	3,4	Elasticity of Substitution	Feenstra (2010, 1994)
$k$	4,2	Shape parameter of the PD	Eaton et al. (2004)
$f$	1,77	Beachhead costs	Felbermayr et al. (2011)
$f_e$	39,57	Start-up costs	Felbermayr et al. (2011)
$\delta$	0.025	Firms' death probability	Ghironi/Melitz (2005)
$\omega$	0,8	Weight of workers' abilities	Keane (1993)
$\alpha$	0,25	Quality requirement	
$\bar{L}$	1	Total labor force	
$P$	1	Price index	

Table 1: Calibration

nature of the general equilibrium without government' activities. Observing (47) and  $u' = 1 - H'/L'$  shows that  $\Gamma_3 \cdot \tilde{\phi}^{\omega} \leq 1$  must hold to ensure  $0 \leq u' \leq 1$ .<sup>26</sup> Put differently, the aggregate labor demand  $H'$  must not exceed the number of active workers  $L'$  in the equilibrium. This condition is c.p. fulfilled if the shape parameter  $k$  is sufficiently high. The reason for this is simple. The higher  $k$ , 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. Thus, our slightly different calibration with  $k = 4.2$  is needed to guarantee the existence of an equilibrium at the starting position, without offending against the empirical findings.

Two other parameters are specific to our approach, namely  $\omega$  and  $\alpha$ . 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 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  $\alpha$ , which captures the strength of the minimum quality requirements. Intuitively,  $\alpha$  should be smaller than 1. We set  $\alpha = 0.25$ , implying that the minimum quality requirement is relatively weak. Thus, the quality of the firm's management,  $\phi$ , is significant higher than is the ability level of its

<sup>26</sup>For a similar problem, see *Egger and Kreckemeier (2009a)*.

least efficient worker,  $\phi^\alpha$ . In our opinion, this should be the case in nearly all firms; nevertheless, an empirical estimation of  $\alpha$  is a task for future research. Additionally, we normalize the price index and total labor force to one without any loss of generality.

## 5.3 Simulation results

### 5.3.1 Trade liberalization

Before we start our discussion of the different market interventions, let us first explain the need for government interference in more detail by evaluating the impact of trade liberalization on  $s = t_w = t_{pw} = t_\pi = 0$ . In line with *Melitz* (2003), we model trade liberalization as a reduction in the iceberg cost  $\tau$ . To be more precise, we compare the model's outcomes before trade liberalization ( $\tau_0 = 1.6$ , point A) and after trade liberalization ( $\tau_1 = 1.3$ , point B). Figure 1 illustrates the results.

As is standard in the literature, trade liberalization increases the FS, and thus the cut-off productivity shifts up. This in turn reduces potential low-skilled job vacancies, the worker selection effect becomes sharper and the number of long-term unemployed persons enhances. On the contrary, the intensified FS leads to an increase in the FRW, which raises labor demand. However, the increasing worker selection effect dominates the FRW effect; thus, employment shrinks and the unemployment rate rises. Furthermore, the FS dominates employment reduction and welfare hence increases. Therefore, the country benefits from trade liberalization on the macroeconomic level because of this welfare hike. The gains of trade are though unequal distributed. On the one hand, firms – especially exporters – and still employed persons gain from trade, whereas on the other, low-skilled workers – by now long-term unemployed persons – and workers losing their employment are harmed by trade liberalization (for a more detailed discussion, see *de Pinto/Michaelis*, 2011 and *Melitz*, 2003).

At this point, the government implements the redistribution schemes. Clearly, all three benefit the losers by paying UB. However, the impact on the trade gains at the macroeconomic level is critical. We know from our partial analysis that UB reduce welfare and destroy the gains of trade but we also have to take into account the implications of the UB' funding. Therefore, we investigate whether the several redistribution schemes destroy or recover the trade gains in order to create a ranking which measures the policy success. Note that in figure 1, the trade gains are equal to the difference between point B (situation after trade liberalization) and point A (situation before trade liberalization) in the welfare plot.

### 5.3.2 Redistribution scheme 1: UB and the wage tax

From our partial analysis, we know that neither UB nor the wage tax influences the FS, leaving the distribution of firms and the number of long-term unemployed persons unchanged. Concerning the labor and goods market outcome, Figure 2 illustrates our simulation results.

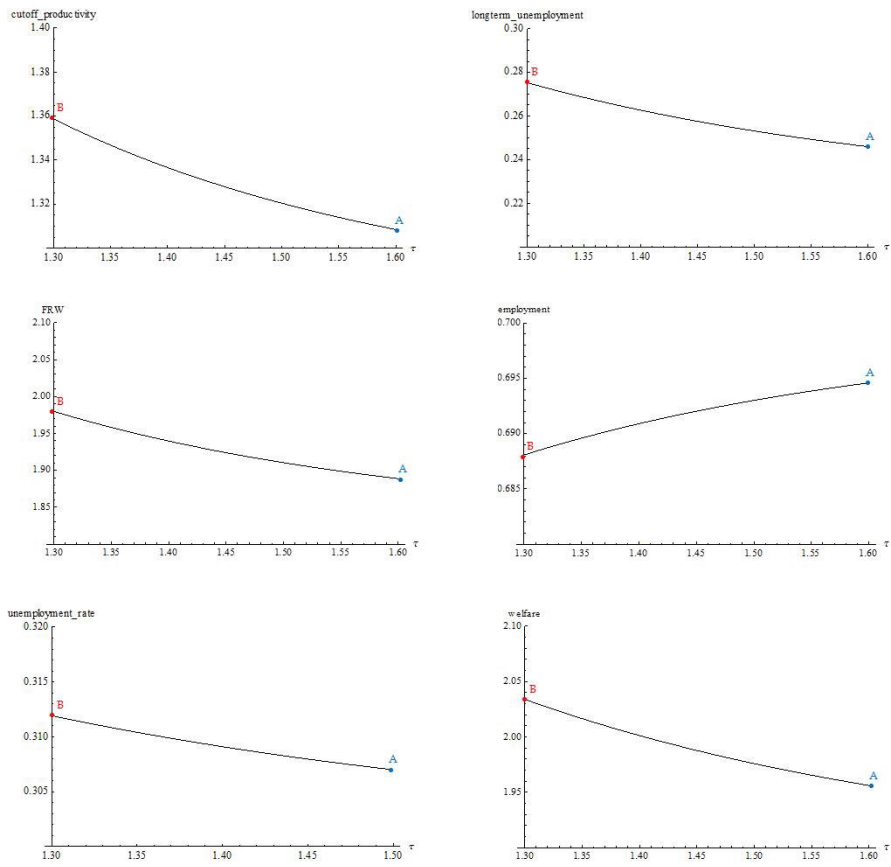


Figure 1: Trade liberalization

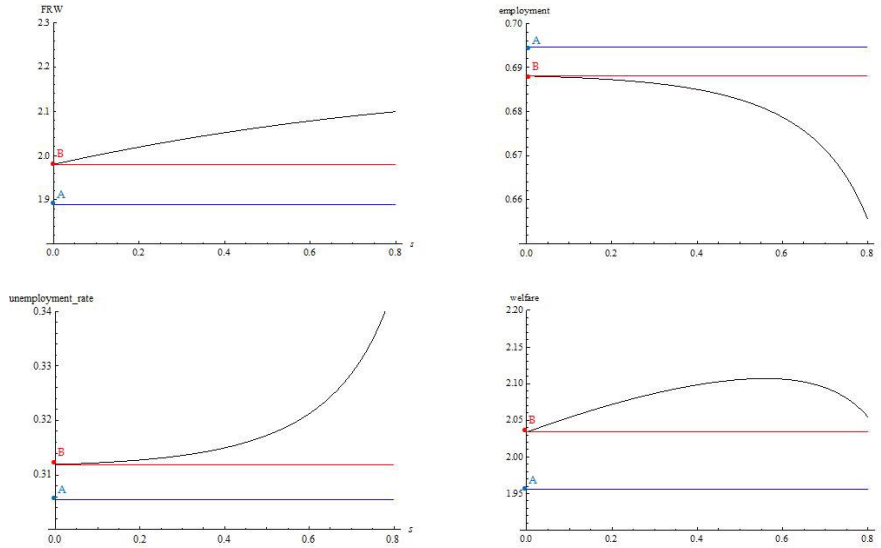


Figure 2: UB and the wage tax

Note that points A and B represent the trade liberalization simulation without the government's interference as shown above. The blue line – starting point A – indicates the threshold level before trade liberalization. The red line – starting from point B – illustrates the corresponding values after trade liberalization. Both are just reference lines in order to rate the policy success. Only the black line shows the simulation result for the redistribution scheme 1, where the respective variable is a function of the political parameter  $s$ .<sup>27</sup>

In accordance to our partial analysis, the FRW increases because of the rise in the upper bound of abilities and average ability level. From this effect, the labor demand rises. However, UB and the wage tax lead to an increase in the target real wage, thereby reducing aggregated labor demand. As reported in Figure 2, the latter effect dominates the former; thus employment decreases respectively the unemployment rate increases. Concerning welfare, the reaction is hump-shaped. On the one hand, the derived employment reduction decreases output and hence the welfare level. On the other hand, the increasing average ability level raises output and the welfare level directly due to the technology assumption. For relatively low values of  $s$  (and accordingly  $t_w$ ), the latter effect dominates, while for relatively higher values the decreasing employment causes a welfare reduction.

Figure 2 also shows the success of the redistribution scheme. Let us first discuss the implications from a microeconomic perspective. Since FS remains constant, the number of long-term unemployed persons does not vary. However, UB unambiguously benefits the *so far* (before the market intervention)

<sup>27</sup>We will also use this exposure also for redistribution schemes two and three.



unemployed person, including the long-term unemployed, since there is no UB at point B (situation after trade liberalization and without the government). By contrast, the combined policy instruments UB and the wage tax raises the unemployment rate. Consequently, the redistribution scheme harms for any value of  $s$  on average those workers who switch from employment with the wage rate  $w'$  to unemployment with UB as the new income. Concerning the winners of trade, the redistribution scheme meets all firms in the same way without changing the distribution of trade gains. However, the increasing FRW benefits the still (after the market intervention) employed workers. To conclude, the government's action puts those in a better position who were unemployed before, but intensifies the negative impact of trade liberalization on the labor market, i.e. the rising unemployment rate.

Nevertheless, the redistribution scheme is successful since the gains of trade at the macroeconomic level are completely recovered at any value of  $s$ . As shown above, the rise in the average ability level prevents the welfare level from shrinking below the value that was achieved after trade liberalization (point B). Consequently, welfare stays above threshold point A and the gains of trade are not destroyed.

**Proposition 1** *Suppose that the government implements UB and chooses the wage tax for its funding. Then, (i) the FS and the number of long-term unemployed persons remain constant, (ii) the FRW increases, (iii) the employment level decreases and aggregate unemployment rate increases and (iv) the welfare variation of  $s$  is hump-shaped. Moreover, the redistribution scheme completely conserves the gains of trade.*

**Proof.** *see text and Figure 2.* ■

### 5.3.3 Redistribution scheme 2: UB and the payroll tax

If the government implements the UB and chooses the payroll tax as its funding, we again find no impact on the FS and on the number of long-term unemployed persons. Figure 3 reports the simulation results.

Not surprisingly, the effects are unique. Both UB (due to a rise in the target real wage) and the payroll tax (due to a decrease in the FRW) forces down the employment level, which leads to a decrease in output and hence welfare.

At the microeconomic level, the redistribution scheme benefits the unemployed persons after trade liberalization, but harms those workers that lose their jobs because of the government's market interference as before. Furthermore, the FRW shifts down, which harms the still employed workers who originally benefitted from trade liberalization. For relatively small values of  $s$ , the trade gains of this group just fall but remain positive – lying between points B and A. If  $s$  exceeds a certain threshold, however, the trade gains of employed workers vanish – the FRW lies under point A.

The same holds true for the gains of trade at the macroeconomic level. If  $s$  is sufficiently low, then the trade gains shrink but not fully disappear. If

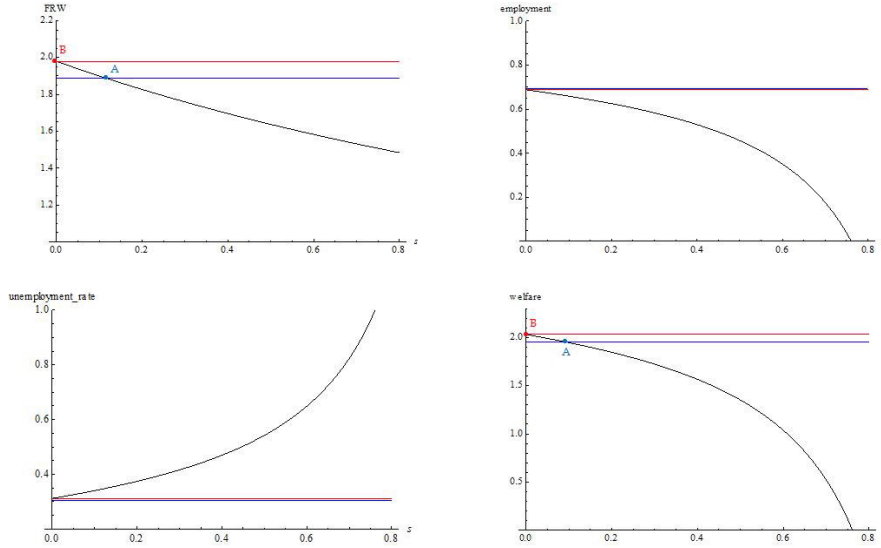


Figure 3: UB and the payroll tax

$s$  is relatively high, trade gains are completely destroyed in response to the redistribution scheme.

**Proposition 2** *Suppose that the government implements the UB and chooses the payroll tax as its funding. Then, (i) the FS and the number of long-term unemployed persons remain constant, (ii) the FRW decreases, (iii) the employment level decreases and aggregate unemployment rate increases and (iv) welfare decreases. Moreover, the gains of trade are destructed partially for relatively low values of  $s$  and they are destroyed completely for relatively high values of  $s$ .*

**Proof.** see text and Figure 3. ■

### 5.3.4 Redistribution scheme 3: UB and the profit tax

We now turn to redistribution scheme 3. Figure 4 reports the simulation results.

Considering the FS first, we observe a reduction in average net profit per firm  $\bar{\pi}_t^{net}$  (not illustrated in the figure) and thus a decline in the cut-off productivity (see partial analysis). Consequently, the distribution of active firms shifts down with two important implications. First, the worker selection effect becomes weaker, meaning that there are more firms demanding low-skilled workers. Consequently, the number of long-term unemployed persons decreases. Second, the average productivity of all domestic firms,  $\bar{\phi}$ , falls. The reduction in  $\bar{\phi}$  yields a decline in the average productivity of all market active firms,  $\bar{\phi}_t$ . This effect, however, is mitigated (but not compensated) by the ES ( $D > 1$ ).<sup>28</sup>

<sup>28</sup>In order not to overload Figure 4, we abstain from presenting the corresponding graph.

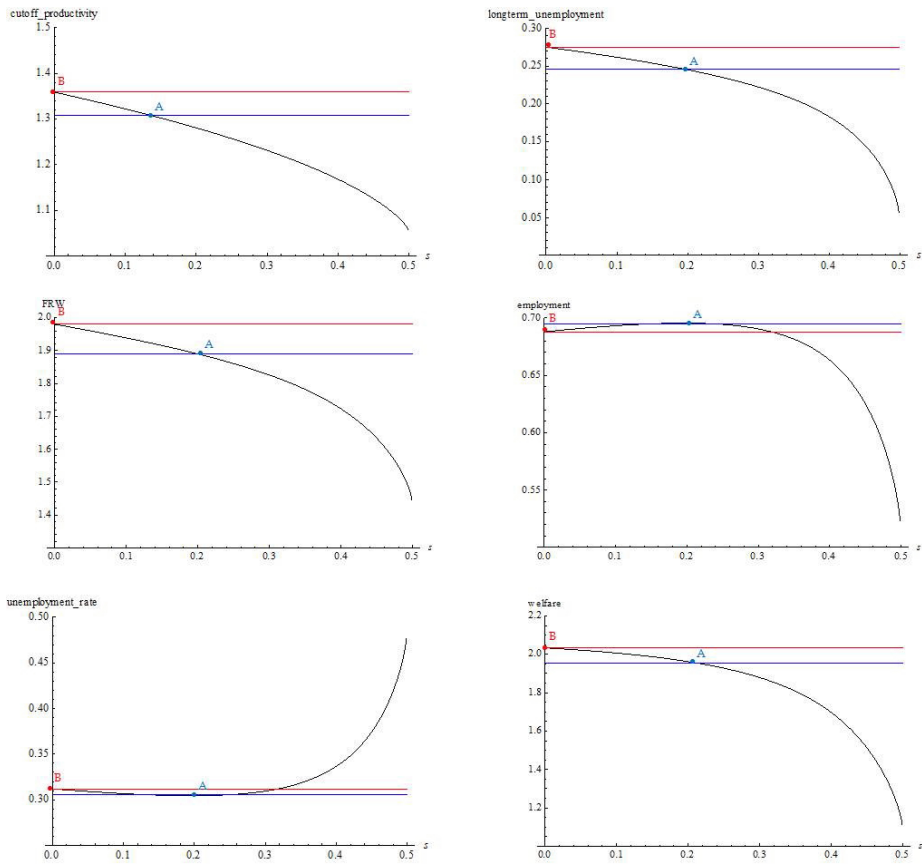


Figure 4: UB and the profit tax

Looking at the labor market, the case of a negative FS ( $\phi^*/\phi^{*'} < 1$  and  $\tilde{\phi}/\tilde{\phi}' < 1$ ) and a positive ES ( $D > 1$ ) prevails because of the former statements. We observe two channels. First, the weaker worker selection (lower number of  $L^l$ ) and the ES dominates the negative employment effect resulting from the decline in the FRW. Thus, the employment level  $H$  increases ( $\omega < \alpha k$ ). Second, due to the implementation of UB, the fallback income and the unions' wage claim enhances, thereby reducing aggregated labor demand  $H$ . It is obvious from Figure 4 that the first effect dominates for relatively low values of  $s$  while the second effect dominates otherwise. The results for the unemployment rate are similar.

Next, we consider output and welfare level. As illustrated in Figure 4, welfare  $Y/\bar{L}$  decreases. Since we have  $\omega + 1 + \alpha > \alpha k$  in our calibration, the combined effect of the decrease in average productivity, in the average ability level and in the FRW dominates the positive effect of the weaker worker selection; output declines. The reduction in  $Y/\bar{L}$  is amplified by the decline in labor demand due to the introduction of UB. The positive impact of the ES cannot change the sign.

Looking at the distributional consequences at the microeconomic level, the situation is more complex than it was before. On the one hand, relatively low-productive firms that now survive on the market are benefitted by the market intervention. Consequently, there are new low-skilled job vacancies, which can be matched with relatively low-skilled workers. Thus, the number of long-term unemployed persons shrinks and low-skilled workers getting a job are better off. On the other hand, decreasing average productivity implies a reduction in firms' profits, which harms firms that were already producing before the market intervention. Furthermore, the still employed workers obtain a loss in terms of the decreasing FRW. Note that although the employment increase at the aggregate level for low values of UB, some workers lose their jobs because of the decreasing FRW and UB. Those workers are thus strictly worsen as explained above.

In regard to the trade gains at the macroeconomic level, we observe that the redistribution scheme continuously decreases welfare and thus the gains of trade. For relatively low values of  $s$ , increasing employment mitigates (but not compensates) the decrease in average productivity. As a result, trade gains shrink but do not completely vanish (welfare level is higher than point A). Afterwards, trade gains disappear due to the redistribution scheme.

**Proposition 3** *Suppose that the government implements UB and chooses the profit tax as its funding. Then, (i) the average productivity decreases, (ii) the number of long-term unemployed persons falls, (iii) the FRW decreases, (iv) the employment and aggregate unemployment rate reaction is (inverse) u-shaped and (v) welfare decreases. Moreover, the gains of trade are destructed partially for relatively low values of  $s$  and they are destroyed completely for relatively high values of  $s$ .*

**Proof.** *see text and Figure 4.* ■

## 6 Conclusion

The contribution of this paper is to investigate the implications of different redistribution schemes by the government as a reaction to the unequal distribution of trade gains. In particular, we assess their impacts on firm selection, (long-term) unemployment and welfare using a positive, comparative static analysis. Three redistribution schemes are distinguished: First, the government implements UB financed by a wage tax. Second, the government elevates a payroll tax as its funding and third, the government finances UB by a profit tax that is exclusively paid by exporting firms.

Looking at the political success, we observe that all three redistribution schemes provide at least some parameter constellation for which a recovery of trade gains is partially possible. The wage tax clearly dominates the others since the gains of trade are completely recovered. The payroll tax and profit tax continuously destroy the gains of trade at which the former achieves this point for lower values of the UB. Thus, we obtain an unequivocal ranking for the chosen funding of the UB: 1. wage tax, 2. profit tax, 3. payroll tax.

Our approach has two limitations. First, welfare is only measured by output per capita. The empirical evidence, however, shows that trade liberalization also influences highly income distribution. Thus, the incorporation of income distributional aspects in the welfare criteria is needed in future research. Second, none of our findings indicates what the government should do in a normative sense. Hence, the implementation of a government's objective function is a straightforward extension of our model.

## 7 Appendix

### Appendix A: Derivation of Eq. (24)

Inserting (21) and the reservation wage of worker  $z_i$ ,

$$b_{z_i} = (1 - t_w)(1 - u(1 - s))(a_{z_i})^\omega \left( w(\tilde{\phi}) \right)^{1-\omega} \quad (\text{A1})$$

into  $w_i = b_{z_i}$  yields  $a_{z_i} = (\theta/(1 - t_w))^{1/\omega} a_{m_i}$ . Substituting (23) into  $a_{z_i} = (\theta/(1 - t_w))^{1/\omega} a_{m_i}$  and noting  $a_i^* = \phi_i^\alpha$ , we obtain (24).

### Appendix B: Derivation of the general equilibrium

For the number of long-term unemployed persons, we use  $P(a < a^*) = 1 - (a^*)^{-k}$  to obtain  $L^l = (1 - (a^*)^{-k})\bar{L}$ . Observing (28), (31) and (36) yields the number of long-term unemployed persons (??). Using  $L = \bar{L} - L^l$ , we get the number of active workers (46).

To calculate the employment, we combine (42) and (44) to eliminate the wage. This leads to

$$\frac{1}{1 + t_w} \kappa \bar{a} \tilde{\phi}_t = A_0^{1/\omega} (1 - u(1 - s))^{1/\omega} \cdot \tilde{\phi}_t^\alpha \quad (\text{B1})$$

The substitution of (43) into (B1) and rearrangement leads at first to the unemployment rate of active workers  $u$ . Inserting this result and (46) into  $H = (1 - u)L$  yields the number of employed active workers (47). By substituting (38) with (28), (31), (36), (46) and (47) into (38), we obtain the aggregate unemployment rate (48).

Concerning welfare, we choose per capita output  $Y/\bar{L}$  as its measurement. Aggregate net profits are used to finance the initial investments  $f_e$  of firms. Thus, only the wage income is available for consumption. Owing to the mark-up pricing rule, the per capita wage income is then equal to a constant share  $\kappa$  of per capita output:  $W/\bar{L} = \kappa Y/\bar{L}$ . Using the technology assumption (5) and (37), the per capita output is  $Y/\bar{L} = M_t q(\tilde{\phi}_t)/\bar{L} = M_t h(\tilde{\phi}_t) \bar{a}(\tilde{\phi}_t) \cdot \tilde{\phi}_t/\bar{L} = M_t \frac{\bar{a}(\tilde{\phi}_t) \tilde{\phi}_t}{\xi_1 \xi_2 \psi_1} \frac{H}{\bar{L}}$ . Observing the definition of  $\psi_1$  as well as (47) and (43), we get the measure of welfare (49).

Finally, we use  $Y = R = (1 + \chi)Mr(\tilde{\phi}_t)$  to calculate the number of firms  $M$ . From (12), we obtain  $r(\tilde{\phi}_t) = \sigma(f + \pi^{net}(\tilde{\phi}_t)/(1 - t_\pi))$ . Observing  $\bar{\pi}^{net} = (1 + \chi)\pi^{net}(\tilde{\phi}_t)$  and (39) yields  $r(\tilde{\phi}_t) = \xi_4 D^\beta$ . Inserting this result into  $M = Y/(1 + \chi)r(\tilde{\phi}_t)$  and using  $\chi = \Omega_2^{-k/\beta}$  leads to (50).

**Appendix C: Derivation of the budget constraints**

The wage tax and payroll tax use the aggregated wage income as a tax base, which is a constant share  $\kappa$  of total output (see above). We immediately obtain  $T_w^{aggr.} = t_w \kappa Y'$  and  $T_{pw}^{aggr.} = t_{pw} \kappa Y'$ .

The tax base of the profit tax is the aggregated profits of exporters:

$$\Pi_{t_x} = \int_0^\infty \pi_t(\phi) M_x \mu_x(\phi) d\phi.$$

As shown by *Egger and Kreickemeier (2009a)*, the general solution of (32) is given by:

$$\tilde{\phi}_x = \left[ \int_0^\infty \phi^\beta \mu_x(\phi) d\phi \right]^{1/\beta}. \quad (C1)$$

Together with (27),  $r(\phi) = (\phi/\tilde{\phi}_t)^\beta r(\tilde{\phi}_t)$ , (C1), (35) and (36), we get  $T_\pi^{aggr.} = t_\pi \chi' M' \left( (1 + \tau^{\sigma-1}) r'(\tilde{\phi}_t)/\sigma - 2f \right)$ .

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