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JEL : F1, F16, H2
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Unemployment Benefits as Redistribution Scheme of Trade Gains – a Positive Analysis*

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April 16, 2012

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 labor markets and heterogeneous workers we show that: (i) there is a threshold level of UB where all trade gains are destroyed, (ii) this threshold differs between different kind of taxes, (iii) there is a clearcut ranking in terms of welfare for the chosen funding of the UB: 1. wage tax, 2. profit tax, 3. payroll tax.

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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 (henceforth RS) 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 the choice of the financial form may amplify, mitigate or even avoid 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 RS 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 RS. 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 RS 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 results are derived from a partial and a total analysis. Investigating the different policy instruments in the partial analysis separately yields four results: First, a higher level of the UB improves the workers' fallback income, the union's target real wage increases, employment and thus welfare decreases. Second, the wage tax funding is neutral at the aggregate level. If the wage tax rate rises, unions enhance their wage claims to hold the net wage constant. However, the fallback income of all workers decreases and the unions' target real wage declines. In the equilibrium, both effects exactly offset each other; the wage tax has no impact on the goods and labor market outcomes.

Third, the payroll tax increases firms' marginal costs reducing the FRW. Employment immediately declines, which also lowers welfare. Fourth, the 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 decline in the average productivity: marginal costs increase, the FRW and employment decrease. Looking at the aggregate output, the decreasing average productivity dominates all potential positive employment effects, welfare unambiguously declines.

In our total analysis, we investigate the impact of the three RS mentioned above. Combining the implications of the partial analysis, we find that for the three RS there is a threshold level of UB where all trade gains are destroyed, but this threshold differs with the UB funding: First, UB financed by a wage tax destruct the gains of trade because of the negative impact of the UB. Due to the wage tax neutrality, however, the intensity of the trade gains destruction is relatively low. Second, UB financed by the payroll tax amplify the gains of trade destruction in comparison to the wage tax case because of the payroll tax implies only negative effects on employment and welfare; the threshold for the level of the UB, where the trade gains are completely destroyed is lower.

Third, UB financed by the profit tax destroys also the gains of trade. Due to the positive impact of the profit tax on low-skilled labor demand, the threshold for the level of the UB, where the trade gains are completely destroyed is higher compared to the case of a payroll tax. However, this channel does not dominate the wage tax neutrality; the threshold level of the UB is lower compared to the wage tax funding. As a result, we obtain an unequivocal ranking for the chosen funding of the UB: 1. wage tax, 2. profit tax, 3. payroll tax.

In the literature, the investigation of RS 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 RS. *Egger* and *Kreickemeier* (2009b) extend the *Melitz* (2003) model using a fair-wage effort model and introducing a government sector. The RS 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 RS. 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 RS 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:

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

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

where P is the corresponding price index. V denotes the mass of all potentially available goods M_t and σ represents the elasticity of substitution between any two varieties ($\sigma > 1$). The index im denotes import variables. 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 υ can be derived from the profit maximization of the final goods producers:

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

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 ϕ, which is Pareto-distributed with $G_\phi(\phi) = 1 - (\phi_{\min}/\phi)^k$ for $\phi \geq \phi_{\min} = 1$ and $k > 1$.[1] 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 $\overline{L}$, who differ in their abilities a_j, $j = 1, ..., \overline{L}$. 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.[2]

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 proportional wage tax T_w paid by all employed workers H and a proportional profit tax T_π paid by exporters M_x. Notably, we assume

[1] Notably, our interpretation of the parameter ϕ is slightly different to that of *Melitz* (2003). We prefer the term entrepreneurial (instead of firm) productivity in order to distinguish between the quality of the management and originality of the business idea, and a firm's total productivity, which also depends on the quality of its employed workers.

[2] *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".

that the tax base of the profit tax, $\pi + \pi_x$, is the exporters' total profit, i.e. the sum of domestic and export profit. Furthermore, the average productivity of firms rises because of trade liberalization, implying that firms on average benefit. Thus, a proportional payroll tax T_{pw} paid by all firms M is introduced by the government. The corresponding proportional tax rates are $t_w \in (0,1)$, $t_\pi \in (0,1)$ and $t_{pw} \in (0,1)$.

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

$$q_i = h_i \phi_i \overline{a}_i, \tag{2}$$

where h_i denotes the number of employees and $\overline{a}_i$ 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 ϕ. For concreteness, we assume:

$$a_i^* = \phi_i^\alpha \qquad \text{with} \qquad \alpha \geq 0. \tag{3}$$

Eq. (3) 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 α denotes the sensitivity of a_i^* with respect to entrepreneurial productivity.[3]

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}. The indifference condition is given by $w_i^{net} = (1-t_w)w_i = b_{z_i}$. For the wage offer w_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 net wage: $\partial a_{z_i} / \partial w_i^{net} > 0$.

The abilities of firm i's employees lie within the interval a_i^* and a_{z_i}, where the limits depend on productivity ϕ_i and wage rate w_i. The average ability of the firm-specific interval is given by (see *de Pinto/Michaelis,* 2011 for the derivation):

$$\overline{a}_i = \Gamma_1 \frac{(a_i^*)^{1-k} - (a_{z_i})^{1-k}}{(a_i^*)^{-k} - (a_{z_i})^{-k}} \qquad \text{with} \qquad \Gamma_1 \equiv \frac{k}{k-1}, \tag{4}$$

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

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

The determination of employment and wages at the sectoral level is modelled as a five-stage game, which we solve by backward induction. In the first stage, firm i participates in the *Melitz* lottery and discovers its entrepreneurial productivity ϕ_i. Given ϕ_i, firm i decides whether to produce or not 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 setting 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 (net) 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

Our analysis at the sectoral level continues to focus at firm i with the entrepreneurial productivity ϕ_i. Firm i can either serve the domestic market only or additionally export goods to the foreign market. We first look at firm i's optimal behavior in the domestic market and take up the endogenous export decision afterwards (see section 2.4).

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

$$\pi_i^{net} \equiv (1 - It_\pi)\left(r_i - (1 + t_{pw})h_i w_i - f\right), \tag{5}$$

where r_i is real revenue. The indicator variable I in Eq. (5) is equal to one if firm i exports and becomes zero otherwise.[4] Each firm faces a constant elasticity demand curve (1). Thus, the firm's revenue $r_i = q_i p_i$ is given by

$$r_i = q_i^{\kappa}(Y/M_t)^{1/\sigma}, \qquad \kappa \equiv 1 - \frac{1}{\sigma}, \tag{6}$$

where κ denotes the degree of competitiveness in the market for intermediate goods. The firm maximizes net profits π_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

$$h_i = \left(\frac{\kappa\phi_i^{\kappa}\overline{a}_i^{\kappa}}{(1 + t_{pw})w_i}\right)^{\sigma}\frac{Y}{M_t}. \tag{7}$$

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, $\overline{a}_i$ 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 $\epsilon_{\overline{a}_i,w_i}$. As shown by *de Pinto* and *Michaelis* (2011) in detail, $\epsilon_{\overline{a}_i,w_i}$ is equal across all firms and (for reasonable parameter settings) smaller than one. Then, the derivation of (7) with respect to w_i proves that $\partial h_i/\partial w_i < 0$ holds for $\epsilon_{\overline{a}_i,w_i} < 1$. 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

$$p_i = \frac{1}{\kappa}\frac{(1 + t_{pw})w_i}{\phi_i\overline{a}_i} \tag{8}$$

is a constant mark-up $1/\kappa$ over marginal costs. Note that p_i is independent of the profit tax rate t_π. 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 π_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:

$$r_i = p_i^{1-\sigma}\frac{Y}{M_t}. \tag{6'}$$

Inserting (6') and $h_i = q_i/(\phi_i\overline{a}_i)$ [see (2)] into (5) yields:

$$\pi_i^{net} = (1 - It_\pi)\left(\frac{r_i}{\sigma} - f\right). \tag{9}$$

[4] Because only exporters pay the profit tax, we have $\pi_i = \pi_i^{net}$ if firm i serves the domestic market only ($I = 0$).

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:

$$EU_{m_i} = \frac{h_i}{n_i}\left(1 - t_w\right) w_i + \left(1 - \frac{h_i}{n_i}\right) b_{m_i}, \tag{10}$$

with b_{m_i} denoting the reservation wage (fallback income) of the median member. 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 $NP_i = EU_{m_i} - \overline{U}_{m_i}$ subject to $\partial r_i / \partial h_i = (1+t_{pw})w_i$ with $\overline{U}_{m_i} = b_{m_i}$ 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.[5] 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:

$$w_i = \frac{\theta}{1 - t_w} b_{m_i} \qquad \text{with} \qquad \theta \equiv \frac{1}{\kappa} > 1. \tag{11}$$

The union generates an economic surplus for its members, which we define as the difference between the wage rate w_i and the fallback income of the median member b_{m_i}. The wage rate w_i is increasing c.p. 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:

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

where $(1 - t_1)\overline{w}_j$ is worker j's net outside wage, ρ represents the discount factor and δ denotes the probability of the firm's death (exogenous and independent of productivity). Therefore, δ can also be interpreted as the probability of job loss for any employee. The likelihood that worker j will switch from unemployment to a job is captured by e_j. The fallback income is defined as the period income

[5] 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.

of an unemployed worker: $b_j \equiv \rho V_j^u$ (see *Layard* and *Nickell*, 1990). From the value functions, we obtain $b_j = \frac{\rho+\delta}{\rho+\delta+e_j} B_j + \frac{e_j}{\rho+\delta+e_j}(1-t_w)\overline{w}_j$.

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

$$\delta\,(1-u_j) = e_j u_j. \tag{12}$$

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:

$$u = u_j = 1 - \frac{H_j}{L_j} \qquad \forall j. \tag{13}$$

Using (12) and (13), the fallback income can be derived as[6]

$$b_j = uB_j + (1-u)(1-t_w)\overline{w}_j. \tag{14}$$

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 $\overline{w}_j$, which is defined as j's expected wage rate in the economy.

Let us have a closer look at the outside wage. The empirical literature shows that wages are determined by both individual characteristics and a country's macroeconomic performance (see, for instance, *Fairris* and *Jonasson*, 2008; *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:

$$\overline{w}_j = (a_j)^{\omega}\left(w(\widetilde{\phi}_t)\right)^{1-\omega} \qquad 0 \leq \omega \leq 1. \tag{15}$$

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

[6] Note that (14) is an approximation, which holds for $\rho u = 0$. For a justification of this simplifying assumption, see *Layard* and *Nickell* (1990).

wage rate, which holds in the general equilibrium, $w(\widetilde{\phi}_t)$, where $\widetilde{\phi}_t$ denotes the entrepreneurial productivity of the representative firm (see below).[7]

The UB of worker j are modelled as a constant share of his net outside wage:

$$B_j = s\,(1-t_w)\,\overline{w}_j, \tag{16}$$

with $0 \leq s \leq 1$ denoting the replacement ratio that is set by the government. Eq. (16) 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' 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 (14) and the bargained wage (11) can be rewritten as

$$b_{m_i} = (1-t_w)\,(1-u(1-s))\,(a_{m_i})^{\omega}\left(w(\widetilde{\phi}_t)\right)^{1-\omega}, \tag{17}$$

$$w_i = \theta\,(1-u(1-s))\,(a_{m_i})^{\omega}\left(w(\widetilde{\phi}_t)\right)^{1-\omega}, \tag{18}$$

respectively. As a result, 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 (11)], 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 $(1-t_1)\,\overline{w}_j$ of the same magnitude and consequently the fallback income declines [see (17)]. The decrease in b_{m_i} countervails the increasing wage claim, leaving the wage rate unaffected from variations of t_w. Thus, a higher value of t_w leads to a one-to-one decrease in the net wage rate $w_i^{net} = (1-t_w)w_i$. Notably, this finding strongly depends on the assumption of using the net outside wage in the computation of the UB [see (16)]. If instead $B_j = s\overline{w}_j$ 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. Thus, we ignore this effect in the following by using (16) exclusively.[8]

Note that owing to heterogeneous individuals, the economic surplus (bargained wage minus reservation wage) differs between union members. Within

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

[8] The corresponding simulation results are available upon request.

the firm's and the union's ability interval, the worker with the minimum qualification obtains the largest rent (lowest reservation wage). The surplus declines with members' ability levels, because of an increasing reservation wage. Member z_i with the highest qualification has a zero surplus, which makes him or her indifferent between taking a job in firm i and looking for a job elsewhere.

2.4 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

$$n_i = \int_{a_i^*}^{a_{z_i}} k a^{-(1+k)} da = (a_i^*)^{-k} - (a_{z_i})^{-k}. \tag{19}$$

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

$$a_{m_i} = 2^{1/k} \left[(a_{z_i})^{-k} + (a_i^*)^{-k} \right]^{-1/k}. \tag{20}$$

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 ϕ_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 net wage equals the reservation wage of the efficient worker z_i: $(1-t_w)w_i = b_{z_i}$. Inserting (18) and the reservation wage of worker z_i,

$$b_{z_i} = (1-t_w)(1-u(1-s))(a_{z_i})^\omega \left(w(\widetilde{\phi}_t) \right)^{1-\omega}$$

yields $a_{z_i} = \theta^{1/\omega} a_{m_i}$. Substituting (20) into the latter and noting $a_i^* = \phi_i^\alpha$, we obtain:

$$a_{z_i} = A^{1/k} \phi_i^\alpha \qquad A \equiv 2\theta^{k/\omega} - 1. \tag{21}$$

Note that a variation of t_w does not influence a_{z_i}. If e.g. t_w declines, the reservation wage and the net wage rate simultaneously decreases, leaving the indifference condition of the efficient worker unaffected.

If a firm knows its entrepreneurial productivity ϕ_i, it sets a minimum ability according to (3) and the ability of the efficient worker is given by (21). Inserting both into (20) and observing (18), we can rewrite the wage rate as:[9]

[9] Note that the wage w_i is increasing in the entrepreneurial productivity ϕ_i. High-

$$w_i = A^{\omega/k}\left(1 - u(1-s)\right)\left(w(\widetilde{\phi}_t)\right)^{1-\omega}\phi_i^{\alpha\omega}. \tag{22}$$

In stage one, firm i participates in the *Melitz* lottery and draws the entrepreneurial productivity ϕ_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 ϕ^*: $\phi_i \geq \phi^*$. In this case, the expected stream of profits is non-negative. The firm with the lowest possible productivity ϕ^* is called the marginal firm.

Concerning the export decision, there are variable iceberg costs $\tau > 1$ besides the already mentioned beachhead cost $f_x \geq 0$. Furthermore, exporting creates a third cost component, i.e. the profit tax on domestic profits $t_\pi \pi_i$ [see (9)], which would be zero if firm i does not export due to our assumption that the profit tax incriminates only exporters. We can derive an export cut-off level ϕ_x^* such that for $\phi_i \geq \phi_x^*$ the additional revenue of exporting is at least as high as the additional costs.[10] In line with *Melitz* (2003), only a fraction of firms engage in exporting.[11] For $\phi_i \geq \phi_x^*$, firms are exporters and produce for both the home and foreign markets ($I = 1$). For $\phi^* \leq \phi_i < \phi_x^*$, firms produce for the home market only ($I = 0$).

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. The net export profit is defined by $\pi_{ix}^{net} \equiv (1 - t_\pi)(r_{ix}/\sigma - f_x - t_\pi \pi_i)$.[12] Profit maximization yields $p_{ix} = \tau p_i$, $q_{ix} = \tau^{-\sigma} q_i$, $h_{ix} = \tau^{1-\sigma} h_i$ and $r_{ix} = \tau^{1-\sigma} r_i$. Thus, the export variables can be expressed as a function of the domestic variables (see also *Melitz*, 2003). Using the simplifying assumption of $f = f_x$ (see *Egger* and *Kreickemeier*, 2009a for a justification) and (9), we can reformulate the net export profit:

$$\pi_{ix}^{net} = (1 - t_\pi)\left((\tau^{1-\sigma} - t_\pi)\frac{r_i}{\sigma} - (1 - t_\pi)f\right). \tag{23}$$

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).

[10] We provide the analytical evidence for this in section 3.2.

[11] This result is connected with the validity of the partitioning condition. We will come back to this issue in section 3.1.

[12] Clearly, the inclusion of $t_\pi \pi_i$ into the export profit function is unconventional. We can justify this approach with an economic and a formal argument. First, $t_\pi \pi_i$ are costs connected to the export decision. If firms export, market shares increase; there are some gains of trade. Only in this case, the government redistributes a fraction of trade gains by imposing the profit tax. Thus, it is plausible to assume that the costs of the profit tax are paid from the additional export profits. In the analogical way, firms bear the payments of the (variable and fixed) trade costs also from π_{ix}. Second, we avoid a discontinuity in the export profit function. If $t_\pi \pi_i$ disappears, firms with a positive export profit up to a certain threshold have no incentive to export because of the profit tax on domestic profits. Note again that the profit tax base is the exporter's total profit. Consequently, not only $t_\pi \pi_i$ have to be considered for the net export profit definition but also $t_\pi \pi_{ix}$.

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

$$a^* = (\phi^*)^{\alpha}. \tag{24}$$

Thus, we divide the labor force $\overline{L}$ into two groups: (i) active[13] 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.

Long-term unemployed persons also receive UB. In contrast to the UB of active workers, we eliminate the worker-specific component. The reason is simple. Since a person with an ability below a^* has no opportunity to get a job in the economy, her/his outside wage drops to zero and according to (16) the UB would be zero as well. To avoid this, we assume that the UB of long-term unemployed persons is a constant share s of the net equilibrium wage rate instead of the worker-specific net outside wage. Formally, we get:

$$B_j^l = s(1 - t_w) w \left(\widetilde{\phi}_t \right) \quad \text{if} \quad j \in (1, a^*]. \tag{25}$$

Notably, Eq. (25) is a special case of the general formulation in (16), which holds if the microeconomic variable in the outside wage disappears ($\omega = 0$).

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 $\widetilde{\phi}_t$ first. By following the step-by-step derivation of *Egger* and *Kreickemeier* (2009a), we get:

$$\widetilde{\phi}_t = \widetilde{\phi} \left[\frac{1}{1+\chi} \left(1 + \chi \tau^{1-\sigma} \left(\frac{\widetilde{\phi}_x}{\widetilde{\phi}} \right)^{\beta} \right) \right]^{1/\beta}, \tag{26}$$

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

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

$$\chi = \frac{1 - G_\phi(\phi_x^*)}{1 - G_\phi(\phi^*)} = \left(\frac{\phi^*}{\phi_x^*}\right)^k, \qquad 0 < \chi < 1. \tag{27}$$

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

$$\widetilde{\phi} = \xi_1^{1/\beta}\phi^*, \tag{28}$$

$$\widetilde{\phi}_x = \xi_1^{1/\beta}\phi_x^*, \tag{29}$$

$$\xi_1 \equiv \frac{k}{k-\beta} \quad \text{with} \quad k > \beta.$$

The inspection of (27), (28) and (29) indicates that the total average productivity $\widetilde{\phi}_t$ depends on the relation between the export cut-off level ϕ_x^* and the cut-off productivity level ϕ^*. To calculate ϕ_x^*/ϕ^* (and hence $\widetilde{\phi}_x/\widetilde{\phi}$), we use the well-known zero cut-off profit condition (henceforth ZPC) (see *Melitz*, 2003). By definition, the marginal firm ϕ^* gains a zero net profit: $\pi^{net}(\phi^*) = \pi(\phi^*) = 0$.[14] From (9) and $\phi_i = \phi^*$, we obtain:

$$r(\phi^*) = \sigma f. \tag{30}$$

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. Using (23) yields:

$$r(\phi_x^*) = \sigma f \Omega \qquad \Omega \equiv \frac{1 - t_\pi}{\tau^{1-\sigma} - t_\pi} > 1, \tag{31}$$

with $\tau^{1-\sigma} \geq t_\pi$ by assumption.[15]

Inserting (30) and (31) into $r(\phi_x^*)/r(\phi^*) = (\phi_x^*/\phi^*)^\beta$, which follows from transformations of (6') and using (28) as well as (29) leads to

$$\left(\frac{\widetilde{\phi}_x}{\widetilde{\phi}}\right)^\beta = \left(\frac{\phi_x^*}{\phi^*}\right)^\beta = \Omega. \tag{32}$$

Next, we combine (27) with (32) to get

$$\chi = \Omega^{-k/\beta}. \tag{28'}$$

[14] Notably, (27) implies $\phi^* < \phi_x^*$. Thus, the marginal firm only produces for the domestic market, concluding $I = 0$ and $\pi^{net}(\phi^*) = \pi(\phi^*)$.

[15] Note that if all firms pay the profit tax, the export decision is independent of t_π and we obtain $r(\phi_x^*) = \sigma f \tau^{\sigma-1}$.

Substituting (32) into (26) and using (28'), we finally obtain:

$$\widetilde{\phi}_t = \widetilde{\phi} D \qquad \text{with} \;\; D \equiv \left(\frac{1 + \tau^{1-\sigma} \chi^{(k-\beta)/k}}{1+\chi} \right)^{1/\beta} > 1. \tag{33}$$

The difference between the two averages $\widetilde{\phi}_t$ and $\widetilde{\phi}$ 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 $\widetilde{\phi}$. 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 $\widetilde{\phi}_t$ decreases relative to $\widetilde{\phi}$. In the *Melitz* world, it is typically assumed that the partitioning condition holds, which implies $\phi^* < \phi_x^*$. Only the 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 $\widetilde{\phi}_t = \widetilde{\phi}$.

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 (32) shows however that c.p. the export productivity cut-off increases in t_π, 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 $\widetilde{\phi}_t$. This mechanism is represented by the parameter D in Eq. (33). As a result, we obtain $\widetilde{\phi}_t > \widetilde{\phi}$ if $t_\pi > 0$ ($D > 1$) and $\widetilde{\phi}_t = \widetilde{\phi}$ if $t_\pi = 0$ ($D = 1$).

The aggregate variables are derived in the standard way with the underlying assumption of an equalized balance of payments. It follows: $P = p(\widetilde{\phi}_t) \equiv 1$, $Y = M_t q(\widetilde{\phi}_t)$ and $R = M_t r(\widetilde{\phi}_t)$. The aggregate gross profit is calculated for the hypothetical case that the profit tax is withhold by exporters. We obtain the standard formulation $\Pi = M_t \pi(\widetilde{\phi}_t)$ (see *Melitz,* 2003). For the employment level, we get:

$$H = M h(\widetilde{\phi}_t) \cdot \xi_1^{\alpha\omega/\beta} \xi_2 \psi_1, \tag{34}$$

$$\xi_2 \equiv \frac{k-\beta}{k-\beta+\alpha\omega}, \quad \psi_1 \equiv D^{\alpha\omega-\beta} \left(1 + \tau^{1-\sigma} \chi^{(\alpha\omega+k-\beta)/k} \right).$$

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 $M_t = M + M_x = M(1+\chi)$.

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

Therefore, we treat the firm with productivity $\widetilde{\phi}_t$ as the representative firm of the economy. Note that the equations for P, Y, R, Π and H are aggregation rules. To determine their levels in the equilibrium, we have to add the firm entry and exit condition and the labor market clearing condition.

Turning to the government sector, we calculate the aggregate levels of the UB, the wage tax, the payroll tax and the profit tax (see Appendix A for the analytical evidence):

$$B = B^l + B^u = s(1 - t_w)\left[w(\widetilde{\phi}_t)L^l + \xi_3 (a^*)^\omega w(\widetilde{\phi}_t)^{1-\omega} uL\right], \tag{35}$$

$$T_w = t_w \kappa Y, \tag{36}$$

$$T_{pw} = t_{pw} \kappa Y, \tag{37}$$

$$T_\pi = t_\pi M_x \left(\pi(\widetilde{\phi}_x) + \pi_x(\widetilde{\phi}_x)\right), \tag{38}$$

where ξ_3 being a constant defined in Appendix A. With (38) at hand, the aggregate net profit is given by:

$$\Pi^{net} = M_t \pi(\widetilde{\phi}_t) - t_\pi M_x \left(\pi(\widetilde{\phi}_x) + \pi_x(\widetilde{\phi}_x)\right). \tag{39}$$

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

$$\overline{u} = 1 - (a^*)^{-k} \frac{H}{L}. \tag{40}$$

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

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 ϕ^*. 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 (30). In a next step, we derive the average net profit per firm $\overline{\pi}_t^{net} \equiv \Pi^{net}/M$ that exists in the economy if the marginal firm gains zero profit. Using (39), $M_t = M(1+\chi)$ and $M_x = \chi M$ yields:

$$\overline{\pi}_t^{net} = (1+\chi)\pi(\widetilde{\phi}_t) - t_\pi \chi(\pi(\widetilde{\phi}_x) + \pi_x(\widetilde{\phi}_x)). \tag{41}$$

Reformulating (9) and (23) for gross domestic and export profits, respectively, substituting $r(\widetilde{\phi}_t) = (\widetilde{\phi}_t/\phi^*)^\beta r(\phi^*)$ as well as $r(\widetilde{\phi}_x) = (\widetilde{\phi}_x/\phi^*)^\beta r(\phi^*)$ and observing (30) as well as (27) leads to $\pi(\widetilde{\phi}_t) = (D^\beta \xi_1 - 1)f$, $\pi(\widetilde{\phi}_x) = (\chi^{-\beta/k}\xi_1 - 1)f$ and $\pi_x(\widetilde{\phi}_x) = (\tau^{1-\sigma}\chi^{-\beta/k}\xi_1 - 1)f$. Inserting these expressions into (41), we finally obtain the average net profit in the presence of the ZPC:

$$\overline{\pi}_t^{net} = (1+\chi)\left(D^\beta \xi_1 - 1\right) f - \chi t_\pi \left((1+\tau^{1-\sigma})\chi^{-\beta/k}\xi_1 - 2\right) f. \tag{42}$$

As a result, the average net profit $\overline{\pi}_t^{net}$ in the economy is independent of ϕ^*, which is a direct consequence of the Pareto distribution properties. Obviously, the aggregate net profit $\Pi^{net} = M\overline{\pi}_t^{net}$ – an equivalent formulation of (39) – additionally depends on the number of firms operating in the market, which is derived in section 3.3.

The FE ensures that all existing firms have an incentive to participate in the *Melitz* lottery. Formally, this requires $f_e = (1 - G_\phi(\phi^*))\,\overline{\pi}_t^{net}/\delta$, 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:[16]

$$\overline{\pi}_t^{net} = (\phi^*)^k \delta f_e. \tag{43}$$

With (42) and (43) at hand, we compute the cut-off productivity level:

$$\phi^* = \left[\left(\begin{array}{c} (1+\chi(t_\pi))\left(D^\beta(t_\pi)\cdot\xi_1 - 1\right) \\ -\chi(t_\pi)\cdot t_\pi\left((1+\tau^{1-\sigma})(\chi(t_\pi))^{-\beta/k}\cdot\xi_1 - 2\right)\end{array}\right)\frac{f}{\delta f_e}\right]^{1/k}. \tag{44}$$

Thus, ϕ^*, $\widetilde{\phi}$ and $\widetilde{\phi}_t$ depend on the profit tax rate t_π. The formulation in (44) fits two special cases that can be found in the literature. First, if there is no profit tax, we have $t_\pi = 0$ and $D = 1$, the cutoff-productivity drops to $\phi_1^* = \left[(1+\chi)(\xi_1 - 1)f/\delta f_e\right]^{1/k}$ (see *Egger/Kreickemeier*, 2009a for the same result). Second, if all firms have to pay the profit tax (not only exporters), $\chi = \tau^{-(\sigma-1)k/\beta}$, $D = 1$ and $\widetilde{\phi}_t = \widetilde{\phi}$ holds because of the export cut-off is then independent of t_π. Immediately, (41) changes to $\overline{\pi}_t^{net} = (1+\chi)\pi(\widetilde{\phi}_t) - t_\pi(\pi(\widetilde{\phi}) + \chi\pi_x(\widetilde{\phi}_x))$. It can be easily shown that $\pi(\widetilde{\phi}) + \chi\pi_x(\widetilde{\phi}_x)$ is equal to $(1+\chi)\pi(\widetilde{\phi}_t)$, which implies $\phi_2^* = \left[(1+\chi)(1-t_\pi)(\xi_1 - 1)f/\delta f_e\right]^{1/k}$ (see *Egger/Kreickemeier*, 2009b for the same result).

[16] Notably, the FE-condition implies that Π^{net} is only used to finance the initial investment costs (measured in units of the final good Y): $Y_e = f_e M_e$, where M_e denotes the mass of firms participating in the *Melitz* lottery. In a stationary equilibrium, firms that are hit by the exogenous death shock have to be replaced by market entering firms – those who pass the *Melitz* lottery successfully: $\delta M = (1 - G_\phi(\phi^*))M_e = (\phi^*)^{-k} M_e$. Using (43) leads to $M_e = M\overline{\pi}_t^{net}/f_e$. Thus, the costs for the initial investments can be rewritten as $Y_e = M\overline{\pi}_t^{net} = \Pi^{net}$, which proofs that aggregate net profits finance Y_e.

One further remark. An increase in ϕ^* 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 ϕ^* have an additional consequence in our setting. If, e.g., ϕ^* increases, the ability cut-off goes up as well [see (24)], 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 $p(\widetilde{\phi}_t) = 1$. Then, the price rule (8) delivers the FRW:

$$w_{PS}(\widetilde{\phi}_t) = \frac{1}{1+t_{pw}} \kappa \overline{a}(\widetilde{\phi}_t(t_\pi)) \cdot \widetilde{\phi}_t(t_\pi). \tag{45}$$

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 (3), the upper bound of abilities (21) and $\phi_i = \widetilde{\phi}_t$ into the average ability (4) yields:

$$\overline{a} = \Gamma_1 \Gamma_2 \left(\widetilde{\phi}_t(t_\pi)\right)^\alpha, \qquad \Gamma_2 \equiv \frac{A - A^{1/k}}{A-1}. \tag{46}$$

An increase in the payroll tax rate leads to a rise in firms' marginal costs, which implies a reduction in the FRW: $\partial w_{PS}/\partial t_{pw} < 0$. On the contrary, the implications of the profit tax rate t_π 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 (22). Taking the macroeconomic variables as given, the target real wage of the (representative) monopoly union can be written as

$$w_{WS}(\widetilde{\phi}_t) = A^{\omega/k} \left(w(\widetilde{\phi}_t(t_\pi))\right)^{1-\omega} (1 - u(1-s)) \cdot \widetilde{\phi}_t(t_\pi)^{\alpha\omega}. \tag{47}$$

In the general equilibrium, we have $w_{PS}(\widetilde{\phi}_t) = w_{WS}(\widetilde{\phi}_t) = w(\widetilde{\phi}_t)$. With this condition, 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 aggregate unemployment rate $\overline{u}$, the measure of welfare $Y/\overline{L}$ and the number of firms M for any given parameter setting of the government (see Appendix B). Using $\widetilde{\phi}_t = D\widetilde{\phi}$, the general equilibrium is given by:[17]

$$L^l = \left(1 - \xi_1^{\alpha k/\beta}\left(\widetilde{\phi}(t_\pi)\right)^{-\alpha k}\right)\overline{L}, \tag{48}$$

$$L = \xi_1^{\alpha k/\beta}\left(\widetilde{\phi}(t_\pi)\right)^{-\alpha k}\cdot\overline{L}, \tag{49}$$

$$H = \frac{\Gamma_3(t_{pw})\cdot\left(\widetilde{\phi}(t_\pi)\cdot D(t_\pi)\right)^{\omega} - s}{1-s}\xi_1^{\alpha k/\beta}\left(\widetilde{\phi}(t_\pi)\right)^{-\alpha k}\cdot\overline{L}, \tag{50}$$

$$\overline{u} = 1 - \frac{\Gamma_3(t_{pw})\cdot\left(\widetilde{\phi}(t_\pi)\cdot D(t_\pi)\right)^{\omega} - s}{1-s}\xi_1^{\alpha k/\beta}\left(\widetilde{\phi}(t_\pi)\right)^{-\alpha k}, \tag{51}$$

$$\frac{Y}{\overline{L}} = \psi_2(t_\pi)\frac{\Gamma_3(t_{pw})\cdot\left(\widetilde{\phi}(t_\pi)\cdot D(t_\pi)\right)^{\omega} - s}{1-s}\cdot\frac{\Gamma_1\Gamma_2 D(t_\pi)^{1+\alpha}\left(\widetilde{\phi}(t_\pi)\right)^{1+\alpha-\alpha k}}{\xi_1^{-\alpha(k-\omega)/\beta}\xi_2}, \tag{52}$$

$$M = \frac{Y(s, t_{pw}, t_\pi)}{(1+\chi(t_\pi))\,\xi_1 D(t_\pi)^{\beta} f\sigma}. \tag{53}$$

The used definitions are:

$$\Gamma_3(t_{pw}) \equiv \left(\frac{\kappa\Gamma_1\Gamma_2}{(1+t_{pw})A^{1/k}}\right)^{\omega} \quad \text{and} \quad \psi_2(t_\pi) \equiv \frac{M_t}{M}\frac{1}{\psi_1} = \frac{1+\chi(t_\pi)}{\psi_1(t_\pi)} > 1.$$

Inserting (50), (53) and (52) into (34) leads to the equilibrium number of employed workers by the representative firm, $h(\widetilde{\phi}_t)$. Owing to (2), we can then determine $q(\widetilde{\phi}_t)$, which completes our analysis at this stage.[18]

[17] 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.

[18] Note that the general equilibrium is still incomplete due to the absence of the government's budget constraint. We close the gap in section five, but prior this, we investigate the policy instruments' partial effects.

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.[19] We regard just one of the government's political parameters at a time, setting the others equal to zero.[20] 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.

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 (42) and (43), the ZPC and FE are both unaffected, leaving cut-off productivity ϕ^* and total average productivity $\widetilde{\phi}_t$ 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 ϕ^*, 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 (48)].

But the employment of active workers is affected. Let us label a situation without the government by an apostrophe, then from (50) we get $H/H' < 1$.[21] 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 (47)]. 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 aggregate unemployment rate $\overline{u}/\overline{u}' > 1$ [see (51)].

The decline in H leads to a reduction in the overall firm's production; the aggregate output Y shrinks. Thus, the country's welfare decreases [see (52)]:

$$\frac{Y/\overline{L}}{Y'/\overline{L}} < 1.$$

[19] 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.

[20] 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.

[21] 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) in case of monopoly unions.

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 find no effect on the goods and labor market outcomes at all. This neutrality is based on three mechanism.

First, the target real wage does not vary with the wage tax rate. Under consideration of (11), the (representative) monopoly union enhances the wage claim for any given level of the fallback income, $w_{ws}(\widetilde{\phi}_t)$ rises. However, as mentioned above, the fallback income declines in t_w, which counteracts the increase in $w_{ws}(\widetilde{\phi}_t)$. In the equilibrium, both effects exactly offset each other and the target real wage remains constant [see (47)].

Second, $\overline{a}(\widetilde{\phi}_t)$ is unaffected. On the one hand, the net wage offer $(1 - t_w)w_{ws}(\widetilde{\phi}_t)$ decreases, which c.p. reduces the firm-specific interval of abilities. On the other hand, the fallback income (or reservation wage) declines, which c.p. expands the firm-specific interval of abilities. With the indifference condition $(1 - t_w)w_{ws}(\widetilde{\phi}_t) = b(\widetilde{\phi}_t)$ it is evident that both effects exactly offset each other, there is no variation in the firms-specific interval of abilities and thus in $\overline{a}(\widetilde{\phi}_t)$.

Third, ϕ^* and $\widetilde{\phi}_t$ are independent of t_w. As a consequence, a^* and thus L^l do not vary. Together with channel two, this implies that the FRW remains constant. With target real wage, FRW and $\widetilde{\phi}_t$ being independent of t_w, goods and labor market outcomes are unaffected and the wage tax is completely neutral for the economy. Looking at the literature, the neutrality result is empirically well-founded (see for instance *Layard* et al., 1991 and *Pissarides,* 1998).

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 (45)]. The rise in prices dampens the demand for each variety, and thus production and employment fall [see (50)]:

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

The employment reduction leads to a one-to-one decrease in aggregate output and welfare [see (52)]:

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

Like the former policy instruments, the FS remains constant. Thus, ϕ^* and $\widetilde{\phi}_t$ 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 (53) 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 ϕ^* in the *Melitz* lottery can still obtain a zero-profit and thus stay at the market.[22]

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. From (41), we obtain:

$$\frac{\overline{\pi}_t^{net}}{\left(\overline{\pi}_t^{net}\right)'} = \frac{(1+\chi)\pi(\widetilde{\phi}_t) - t_\pi \chi(\pi(\widetilde{\phi}_x) + \pi_x(\widetilde{\phi}_x))}{(1+\chi')\pi'(\widetilde{\phi}_t')}.$$

The profit tax operates through three channels. First, $dt_\pi = t_\pi$ c.p. reduces average net profits in the economy directly. Second, Eq. (28') shows that the probability of being an exporter declines. Thus, $(1+\chi)/(1+\chi') < 1$ holds, which also reduces $\overline{\pi}_t^{net}$. 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 ϕ^*: $\widetilde{\phi}_t/\widetilde{\phi}_t' = D > 1$ [see (33)], inducing $\pi(\widetilde{\phi}_t)/\pi'(\widetilde{\phi}_t') > 1$. Hence, the average net profit per firm increases. As a result, channels one and two reduce $\overline{\pi}_t^{net}$; channel three, however, increases $\overline{\pi}_t^{net}$. The profit tax effect on the ZPC and hence on $\overline{\pi}_t^{net}$ is ambiguous.[23]

Owing to Pareto-distributed entrepreneurial productivities, the ZPC uniquely determines $\overline{\pi}_t^{net}$. For simplicity, let us assume that $\overline{\pi}_t^{net}$ decreases in response to the introduction of t_π, i.e. channels one and two dominate channel three. The consequences for the economy are straightforward. Since $\overline{\pi}_t^{net}$ declines, the present value of average net profits $(1 - G(\phi^*))\overline{\pi}_t^{net}/\delta$ decreases for any given level of ϕ^*. 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

[22] Recall that in every period, a fraction of firms are hit by an exogenous death shock δ 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: $\delta M = (1-G(\phi^*))M^e$. Thus, at any point of time, there are firms that participate in the *Melitz* lottery and potentially observe ϕ^* as its productivity.

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

costs and enter the market.[24] Analytically, ϕ^* decreases, which in turn diminishes the FS, implying a decrease in the average productivity of all domestic firms $\widetilde{\phi}$ [see (28)]. Notably, the inverse conclusion holds if $\overline{\pi}_t^{net}$ increases.

Let us turn to the influences on the labor and goods market. Based on our findings, the variation in $\overline{\pi}_t^{net}$ and thus the sign of the FS is ambiguous. The distribution of active firms may shift up or down with the corresponding consequences for $\widetilde{\phi}$ [see (28)] and c.p. for $\widetilde{\phi}_t$ [see (33)]. 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 $\widetilde{\phi}_t$ for any given level of ϕ^*. In order to separate both elements, we divide $\widetilde{\phi}_t$ according to (33) into the FS element $\widetilde{\phi}$ and the ES element D. Thus, we can distinguish two cases:

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

The lower FS changes the segregation of the labor force. From (48) and (49), we get:

$$\frac{L^l}{L^{l\prime}} = \frac{1 - \xi_1^{\alpha k/\beta} \cdot \widetilde{\phi}^{-\alpha k}}{1 - \xi_1^{\alpha k/\beta} \cdot \left(\widetilde{\phi}'\right)^{-\alpha k}} < 1 \quad \text{and} \quad \frac{L}{L'} = \left(\frac{\widetilde{\phi}}{\widetilde{\phi}'}\right)^{-\alpha k} > 1.$$

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 (50):

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

Weaker worker selection increases employment H. But there are two additional effects. First, the lower FS and thus the decrease in $\widetilde{\phi}$ enhance the marginal costs of the representative firm, shifting down the FRW and labor demand. The employment of active workers decreases.[25] 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

[24] In a more technical reasoning, the decline in $(1 - G(\phi^*))\overline{\pi}_t^{net}/\delta$ injured the FE and thus the existence of a stationary equilibrium (see *Melitz*, 2003). Therefore, the cut-off productivity ϕ^* decreases, raising the probability of getting a favorable draw $1 - G(\phi^*)$ and thus increasing the present value of $\overline{\pi}_t^{net}$ until the FE holds again [see (43)].

[25] This effect is mitigated by a decrease in the target real wage. According to (3), 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 (15)], 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.

of the ES may countervail this. Hence, the overall employment effect depends on the parameter setting. In the same way, the aggregate unemployment rate $\overline{u}$ decreases for $0 < \omega < \alpha k$, but its variation is ambiguous for $\omega > \alpha k$ [see (40)].

Concerning the impact on welfare, we can combine (52) to obtain:

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

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 ω. Third, owing to the technology assumption (2), the weaker FS (lower $\widetilde{\phi}$) directly reduces output one-to-one. Fourth, the decrease in $\widetilde{\phi}$ causes a fall in average abilities of the active workers [see (46)]. This reduces output by the factor α. 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.[26] The implications are straightforward. For $\omega + 1 + \alpha < \alpha k$, the positive worker selection effect dominates the negative effects of reducing $\widetilde{\phi}$; 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 ($\phi^*/\phi^{*\prime} > 1$ and $\widetilde{\phi}/\widetilde{\phi}' > 1$) 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 $\widetilde{\phi}$) 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 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-dependet. 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 $\omega + 1 + \alpha < \alpha k$.

[26] Notably, also ψ_2 depends on the profit tax rate and hence we also have to look at ψ_2/ψ_2' in order to complete the partial welfare effect. Howover, simulations, which are available upon request the author, show that $\psi_2/\psi_2' \approx 1$ holds for any value of t_π. Thus, we ignore this channel in the following.

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_π 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 τ (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.[27] 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.[28]

Formally, the budget constraint is always computed for the general equilibrium at the starting position and we thus indicate the respectively variables with an apostrophe in the following.[29] Using (35), (36), (37) and (38), we distinguish three possible RS with three separate budget constraints.

RS 1: UB and the wage tax

$$s\left[w'(\widetilde{\phi}_t')L^{l\prime} + \xi_3\left(a^{*\prime}\right)^{\omega} w'(\widetilde{\phi}_t')^{1-\omega}u'L'\right] = t_w \kappa Y'. \tag{54}$$

RS 2: UB and the payroll tax:

$$s\left[w'(\widetilde{\phi}_t')L^{l\prime} + \xi_3\left(a^{*\prime}\right)^{\omega} w'(\widetilde{\phi}_t')^{1-\omega}u'L'\right] = t_{pw} \kappa Y'. \tag{55}$$

RS 3: UB and the profit tax:

$$s\left[w'(\widetilde{\phi}_t')L^{l\prime} + \xi_3\left(a^{*\prime}\right)^{\omega} w'(\widetilde{\phi}_t')^{1-\omega}u'L'\right] = t_\pi M_x'\left(\pi'(\widetilde{\phi}_x') + \pi_x'(\widetilde{\phi}_x')\right). \tag{56}$$

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_π, 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

[27] Note that we abstain from mixing the three sources of income in order to consider the diverging effects of the differential taxes separately.

[28] 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).

[29] Recall that the apostrophe denotes the $s = t_w = t_{pw} = t_\pi = 0$ case.

Parameter	Value	Interpretation	Source
τ_0, τ_1	1.6, 1.3	Iceberg trade cost	Ghironi/Melitz (2005)
σ	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)
δ	0.025	Firms' death probability	Ghironi/Melitz (2005)
ω	0,8	Weight of workers' abilities	Keane (1993)
α	0,25	Quality requirement	
$\bar{L}$	1	Total labor force	
P	1	Price index	

Table 1: Calibration

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 nature of the general equilibrium without government' activities. Observing (50) and $u' = 1 - H'/L'$ shows that $\Gamma_3 \cdot \widetilde{\phi}'^{\omega} \leq 1$ must hold to ensure $0 \leq u' \leq 1$.[30] 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

[30] For a similar problem, see *Egger* and *Kreickemeier* (2009a).

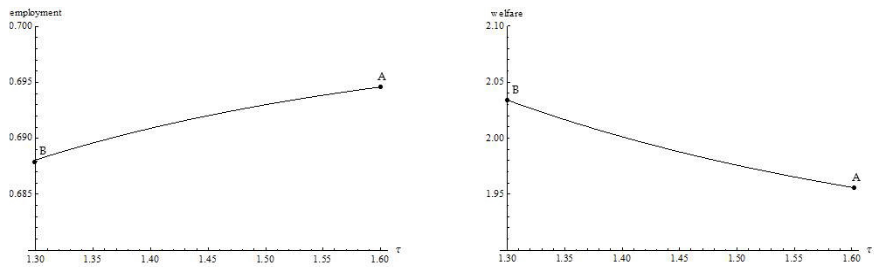

Figure 1: Trade liberalization

an equilibrium at the starting position, without offending against the empirical findings.

Two other parameters are specific to our approach, namely ω and α. The parameter ω, measuring the weight of the abilities in the wage determination, has been estimated only in a few studies. *Keane* (1993) claims that 84 percent of wage differences across industries are explained by individual fixed effects, while only 16 percent can be traced back to industry dummies. The strong weight of individual characteristics in the wage determination is confirmed by, for instance, *Fairris* and *Jonasson* (2008) and *Holmlund* and *Zetterberg* (1991). Hence, a value of $\omega = 0.8$ does not seem at odds with the empirical literature. Unfortunately, to the best of our knowledge, there is no empirical estimation for the parameter α, which captures the strength of the minimum quality requirements. Intuitively, α should be 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, ϕ, is significant higher than is the ability level of its least efficient worker, ϕ^{α}. In our opinion, this should be the case in nearly all firms; nevertheless, an empirical estimation of α 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 τ. 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 RS. 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 RS amplify or mitigate the destruction of 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 RS 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.[31]

We have shown in our partial analysis that the wage tax is neutral for the labor and goods market outcomes at the aggregate level. Thus, the partial effect of the UB translates one-to-one in the total effect of RS 1. The target real wage increases, but since the FRW remains constant, firms reduce their labor demand. Employment decreases respectively the unemployment rate increases. Concerning welfare, the derived employment reduction decreases output per capita.

Let us discuss the distributional implications of the RS 1 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) 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 unemployment rate increases

[31] Note that points A and B represent the trade liberalization simulation without the government's interference as shown above. The black line – starting point A – indicates the threshold level before trade liberalization. The dashed 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 curve shows the simulation result for the RS 1, where the respective variable is a function of the political parameter s. We will use this exposure also for redistribution schemes 2 and 3.

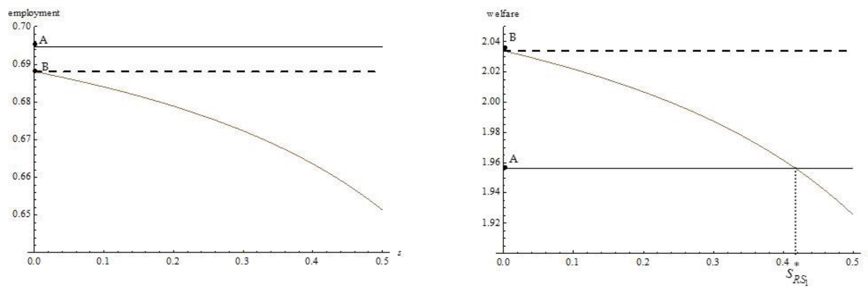

Figure 2: UB and the wage tax

as a consequence of the RS, which harms on average those workers who switch from employment with the wage rate w' to unemployment with UB as the new income. To conclude, the government's action puts those in a better position who were unemployed at point B, but intensifies the negative impact of trade liberalization on the labor market, i.e. the rising unemployment rate.

Looking at the macroeconomic level, the derived welfare reduction implies a destruction of trade gains. As illustrated in Figure 2, there is a partially destruction for relatively low values of s (and hence UB), but if s exceeds the threshold level $s^*_{RS_1}$, the gains of trade are completely 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 does not vary, (iii) the employment level decreases and aggregate unemployment rate increases and (iv) the welfare level declines. If s exceeds a critical threshold, $s \geq s^*_{RS_1}$, then the gains of trade will completely destroyed.*
Proof. *see text and Figure 2.* ■

5.3.3 RS 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 RS 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.

We again find the gains of trade destruction at the macroeconomic level. If s is sufficiently low, then the trade gains shrink but not fully disappear.

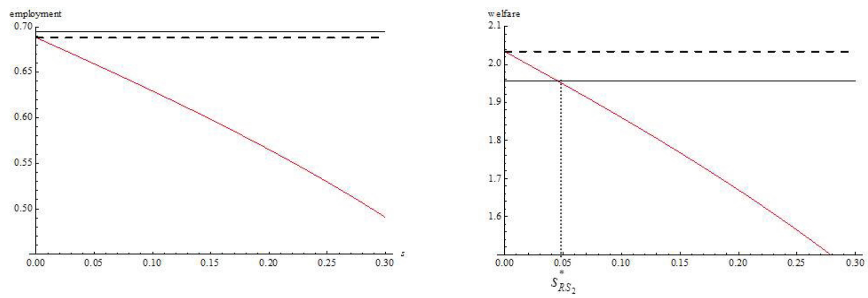

Figure 3: UB and the payroll tax

If s exceeds the threshold level $s^*_{RS_2}$, trade gains are completely destroyed in response to the RS. Notably, $s^*_{RS_2}$ is lower than $s^*_{RS_1}$ because of the payroll tax adds a further negative impact on employment and welfare to the UB effect, while the wage tax is neutral as shown above. Thus, RS 2 amplifies the gains of trade destruction.

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. If s exceeds a critical threshold, $s \geq s^*_{RS_2}$, then the gains of trade will completely destroyed. Moreover, $s^*_{RS_2} < s^*_{RS_1}$ holds; the trade gains destruction is amplified compared to RS 1.*
Proof. *see text and Figure 3.* ■

5.3.4 RS 3: UB and the profit tax

We now turn to RS 3 where UB are financed by a profit tax paid by exporters. Figure 4 reports the simulation results (see blue line). Additionally, we simulate our model in case of the profit tax is paid by all firms (see blue dotted line). While we focus on the former, we explore the main difference between both cases at the end of this section.

At first, one important remark. Due to the export cut-off condition (31), the maximum value of the profit tax rate is given by $\tau^{1-\sigma} = t_\pi^{\max}$. If t_π exceeds this threshold, no firm, independent of their entrepreneurial productivity, has an incentive to export – tax revenue and UB would be zero. Moreover, we also see from (31) that if t_π converges to $t_\pi^{\max}$, the ratio between $\widetilde{\phi}_x$ and $\widetilde{\phi}$ increases exponentially. Using (56), our simulation indicates that for $s \leq s^{\max} = 0.25$, t_π is sufficiently lower than $t_\pi^{\max}$ to avoid $\widetilde{\phi}_x \gg \widetilde{\phi}$ and complications from this unrealistic setting.

Considering the FS, we observe a reduction in average net profit per firm $\overline{\pi}_t^{net}$ (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

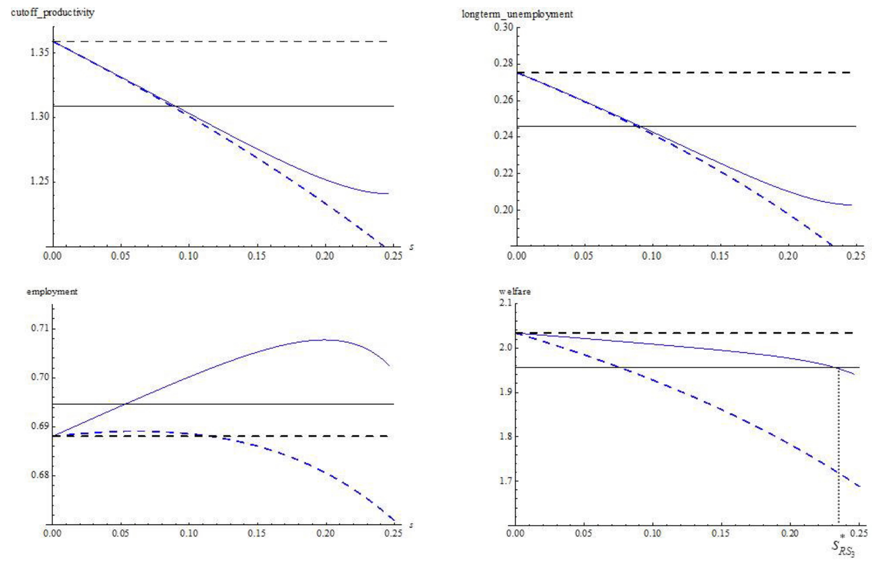

Figure 4: UB and the profit tax

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, $\widetilde{\phi}$, falls. The reduction in $\widetilde{\phi}$ yields a decline in the average productivity of all market active firms, $\widetilde{\phi}_t$. This effect, however, is mitigated (but not compensated) by the ES ($D > 1$).

Looking at the labor market, the case of a negative FS ($\phi^*/\phi^{*\prime} < 1$ and $\widetilde{\phi}/\widetilde{\phi}' < 1$) 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 aggregate 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 $Y/\overline{L}$ 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 $Y/\overline{L}$ 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 RS 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. If s exceeds the threshold level $s^*_{RS_3}$, trade gains disappear due to the RS.

Compared to RS 2, we find that there is again an additional negative impact through the weaker FS channel (average productivity decreases), but there are also two positive influences, namely the increasing labor demand for low-skilled workers and the ES. Both cannot compensate the former, but they mitigate the gains of trade destruction in comparison to the payroll tax scenario. However, the overall negative welfare effect of the profit tax still amplifies the trade gains destruction compared to the neutral wage tax funding: $s^*_{RS_2} < s^*_{RS_3} < s^*_{RS_1}$.

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. If s exceeds a critical threshold, $s \geq s^*_{RS_3}$, then the gains of trade will completely destroyed. Moreover, $s^*_{RS_2} < s^*_{RS_3} < s^*_{RS_1}$ holds; the trade gains destruction is amplified compared to RS 1 but mitigated compared to RS 2.*

Proof. *see text and Figure 4.* ■

If the profit tax is paid by all firms, ϕ^*_x is independent of t_π and thus the ES vanishes ($D = 1$). As a consequence, the reduction of ϕ^* becomes relatively stronger, implying also that the decline in the number of long-term unemployment increases compared to the former case. However, the hump-shaped reaction of H is smaller because of the decrease in $\widetilde{\phi}_t$ is not mitigated from the ES. For the same reason, the welfare decline and thus the gains of trade destruction becomes stronger. However, $s^*_{RS_2} < s^*_{RS_3} < s^*_{RS_1}$ is still fulfilled.

6 Conclusion

The contribution of this paper is to investigate the implications of different RS 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 RS 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.

Using a *Melitz*-type model of international trade with unionized labor markets and heterogeneous workers we show that for the three RS there is a threshold level of UB where all trade gains are destroyed, but this threshold differs with the UB funding. The wage tax clearly dominates the others because of its neutrality. The payroll tax and profit tax amplifies the gains of trade destruction in comparison to the wage tax. However, the latter dominates the former because the positive impact on low-skilled labor demand. Thus, we obtain an unequivocal ranking for the chosen funding of the UB: 1. wage tax, 2. profit tax, 3. payroll tax. The ranking does not change in the special case that all firms pay the profit 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: *Government sector*

Using (25), we calculate the aggregate UB of long-term unemployed persons: $B^l = s(1-t_w)w(\widetilde{\phi}_t)u^l L^l$. The aggregate UB of unemployed active workers is given by

$$B^u = \int_{a^*}^{\infty} s(1-t_w)a^{\omega} w \left(\widetilde{\phi}_t\right)^{1-\omega} \mu(a)uLda,$$

with $\mu(a) = g_a(a)/(1-G_a(a^*))$ representing the distribution of abilities conditional on $a \geq a^*$, i.e. the ability distribution of active workers. Solving the integral leads to $B^u = s(1-t_w)\xi_3(a^*)^{\omega} w \left(\widetilde{\phi}_t\right)^{1-\omega} uL$ with $\xi_3 \equiv k/(k-\omega)$. Using $B = B^l + B^u$ and $u^l = 1$, we obtain the aggregate UB (35).

The wage tax and payroll tax use the aggregate wage income as a tax base, which is a constant share κ of total output because of the mark-up pricing rule. We immediately get the aggregate tax revenues (36) and (37). The aggregate profit tax revenue is given by

$$T_\pi = t_\pi \left(\int_{\phi_x^*}^{\infty} \pi(\phi) M_x \mu_x(\phi) d\phi + \int_{\phi_x^*}^{\infty} \pi_x(\phi) M_x \mu_x(\phi) d\phi \right),$$

with $\mu(\phi) = g_\phi(\phi)/(1 - G_\phi(\phi_x^*))$ denoting the productivity distribution of exporting firms. Reformulating (9) and (23) for gross profits, noting $\phi_i = \phi$ as well as $r(\phi) = (\phi/\widetilde{\phi}_x)^\beta r(\widetilde{\phi}_x)$ implies

$$T_\pi = t_\pi \left(\frac{r(\widetilde{\phi}_x)}{\sigma} \widetilde{\phi}_x^{-\beta} M_x \left(\int_{\phi_x^*}^{\infty} \phi^\beta \mu_x(\phi) d\phi + \tau^{1-\sigma} \int_{\phi_x^*}^{\infty} \phi^\beta \mu_x(\phi) d\phi \right) - 2fM_x \right). \tag{A1}$$

As shown by *Egger* and *Kreickemeier* (2009a), the general solution of (29) is given by:

$$\widetilde{\phi}_x = \left[\int_0^{\infty} \phi^\beta \mu_x(\phi) d\phi \right]^{1/\beta}. \tag{A2}$$

Combining (A1) and (A2) leads to (38).

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 $L^l = (1 - (a^*)^{-k})\overline{L}$. Observing (24), (28) and (33) yields the number of long-term unemployed persons. Using $L = \overline{L} - L^l$, we get the number of active workers.

To calculate the employment, we combine (45) and (47) to eliminate the wage. This leads to

$$\frac{1}{1+t_w} \kappa \overline{a} \widetilde{\phi}_t = A_0^{1/\omega} (1 - u(1-s))^{1/\omega} \cdot \widetilde{\phi}_t^{\alpha}. \tag{B1}$$

The substituting of (46) into (B1) and rearrangement leads at first to the unemployment rate of active workers u. Inserting this result and (49) into $H = (1-u)L$ yields the number of employed active workers. By substituting (40) with (24), (28), (33), (49) and (50) into (40), we obtain $\overline{u}$.

Concerning welfare, we choose per capita output $Y/\overline{L}$ 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. As mentioned above, we have $W/\overline{L} = \kappa Y/\overline{L}$ due to mark-up pricing. Using the technology assumption (2) and (34), the per capita output is $Y/\overline{L} = M_t q(\widetilde{\phi}_t)/\overline{L} = M_t h(\widetilde{\phi}_t)\overline{a}(\widetilde{\phi}_t)\cdot\widetilde{\phi}_t/\overline{L} = \frac{M_t}{M} \frac{\overline{a}(\widetilde{\phi}_t)\cdot\widetilde{\phi}_t}{\xi_1\xi_2\psi_1} \frac{H}{\overline{L}}$. Observing (46) and (50 as well as $M_t/M = 1 + \chi$, we get the measure of welfare.

Finally, we use $Y = R = (1+\chi)Mr(\widetilde{\phi}_t)$ to calculate the number of firms M. Reformulating (9) as gross profits and observing $\pi(\widetilde{\phi}_t) = (D^\beta \xi_1 - 1)f$, we obtain $r(\widetilde{\phi}_t) = D^\beta \xi_1 f \sigma$, which leads to the number of firms operating in the market.

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