Comparative Advantage and Skill-Specific Unemployment*

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Preliminary draft - comments highly welcome!

Abstract

We introduce unemployment and endogenous selection of workers into different skill classes in a trade model with two sectors and heterogenous firms in order to study the distributional consequences and the skill-specific unemployment effects of trade liberalization. We show that the gains from trade will be distributed very unequally: Unskilled (skilled) workers loose in terms of real wages and employment levels in the skill-intensive (unskill-intensive) sector. However, the inequality of workers between sectors is much larger for skilled labor than for unskilled labor. On average, unemployment among unskilled workers increases when a skill abundant countries opens up to trade.

Key words: Comparative advantage; heterogeneous firms; labor market frictions; unemployment; trade liberalization

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1 Introduction

> *The debate preceding the vote on the North American Free Trade Agreement (NAFTA) in the U.S. House of Representatives and the U.S. Senate reveals that, of the 141 anti-NAFTA statements made, 112 were of the form "NAFTA will destroy jobs" while, of the 219 pro-NAFTA statements made, 199 were of the form "NAFTA will create jobs." (Baldwin and Magee, 2000)*

What are the effects of trade liberalization? The existence of gains from trade is one of the core propositions of trade theory. But at the same time the neoclassical models reveal that there are both winners and losers. While the Heckscher-Ohlin model emphasis the role of country factor abundance and industry factor intensity for factors that are perfectly mobile between sectors, the Ricardo-Viner model assumes factors that are specific to sectors.

The distributional consequences of trade liberalization in the Heckscher-Ohlin model are summarized by the Stolper-Samuelson Theorem (Stolper and Samuelson, 1941). The Stolper-Samuelson Theorem predicts that trade liberalization will benefit an economy's relatively abundant factor and harm the economy's relatively scarce factor. This statement is true, regardless where these factors are employed. The reason is that the factors are fully mobile between sectors. Restricting the mobility of factors leads to quite different conclusions. Assuming that some factors are specific to sectors, as the Ricardo-Viner Model does, will lead to gains for the factors that are tied to the economy's export sector and harm those factors that are tied to the economy's import sector. The reason is that factors are not mobile and only the export sector expands after trade liberalization. However, there are several limitations when using these models for actual evaluation of trade policy consequences.

As the quote at the beginning emphasizes, unemployment is a core issue in the political and public debate about trade liberalization. Or, as Krugman (1993) put it: *"One thing that both friends and foes of free trade seem to agree on is that the central issue is employment."* However, the use of frictionless factor markets in the neoclassical trade models rules out equilibrium unemployment by assumption. Further, there is no scope for firm dynamics, which makes it impossible to account for the empirical evidence that much of the observed reallocation occurs across firms within industries instead between industries (see Attanasio, Pinelopi and Pavcnik (2004) and Levinsohn (1999)).

In this paper we present an alternative model for evaluating trade liberalization. Our model is able to make progress in the discussed limitations of the traditional models, while it highlights the role of the mobility assumption for the distributional consequences of trade liberalization. The model incorporates various features in order to capture the most important stylized facts.

First, we allow for heterogeneous firms with varying productivities, generating differences in firm sizes and export status. As a consequence, trade liberalization leads to reallocation of resources not only across firms within industries but also across industries. The assumption of heterogenous firm sizes and "selection in to export markets"[1] are well in line with recent empirical evidence about firms and trade (see Dunne, Roberts and Samuelson (1989); Davis and Haltiwanger (1992); Bernard and Jensen (1995, 1999, 2004); Roberts and Tybout (1997); Clerides, Lach and Tybout (1998); and Bartelsman and Doms (2000)).

Second, we assume search and matching frictions in the labor market, leading to equilibrium unemployment. In order to gather the gains from trade, reallocation of resources is necessary to specialize in the comparative advantage sectors. In this process of reallocation, some workers may lose their jobs. They have then to undergo a period of active job search, before they hopefully find new employment.[2] The search and matching framework form Mortensen and Pissarides (1999), summarized in Pissarides (2000), is a useful framework to capture the idea that reallocations are associated with fricitions, leading to steady-state equilibrium unemployment.

Third, we allow for comparative advantages, by considering different sectors and factors. This gives rise to specialization patterns that highlight Heckscher-Ohlin forces operating not only across industries, but also across firms within industries (for recent empirical evidence see Bernard, Jensen and Schott (2006)). Allowing for different sectors and factors re-invents the reallocation of resources across industries and countries as well as changes in relative factor rewards, which is largely ignored by the recent research on heterogeneous firms (with a notable exception given by Bernard, Redding and Schott (2007, henceforth BRS)). Hence, in the tradition of the Heckscher-Ohlin model, there is mobility of factors between sectors.

Fourth, the model incorporates an endogenous selection of people to sectors and skill-classes. We observe a wide spread of different skill compositions between countries. According to OECD (2007), the share of the population attaining the tertiary level of education can range from 54% for Canada to 20% for Slovenia. It is common in international trade to assume an exogenously given endowment of unskilled and skilled workers. However, if one focusses on the reallocation of resources due to trade liberalization in the long-run, one may want to allow for the possibility of training. Training leads unskilled workers to upgrade their skills and may improve their job opportunities by finding a high-skilled job.

Our model builds upon the model of BRS and combines features of the labor market similar to Felbermayr, Pratt and Schmerer (2008), Helpman and Itskhoki (2008), and Helpman, Itskhoki, and Redding (2008a,b). While BRS embed het-

[1] "Selection into export markets" describes the fact that only the most productive firms export to foreign markets, whereas less productive firms sell there products domestically.

[2] Scheve and Slaughter (2001) analyze how American workers perceive globalization.

erogeneous firms in a model of comparative advantage, and hence incorporate firm dynamics, they stick to the assumption of perfect labor markets. This framework can simultaneously explain why some countries export more in certain industries than in others, why additionally intra-industry trade is observed and why some firms export and others do not. While these are important features we want to preserve, our model additionally allows for a discussion of the unemployment and skill-composition effects of trade liberalization.

There are quite a few studies dealing with the unemployment effects of trade liberalization. We just want to mention four very distinct and recent papers. Egger and Kreickemeier (2008a) allow for three choices of an individual: (i) run a firm, (ii) become self-employed, (iii) be a worker. In equilibrium, the marginal individual must be indifferent between those three choices. They then study the effect on income inequality and unemployment between these groups of workers and show that international trade increases unemployment, income inequality between entrepreneurs and workers, and inequality within these two subgroups of individuals. Egger and Kreickemeier (2008b) focus on the selection of workers into high productivity firms. In this framework they are able to explain within group inequality. Unemployment is due to a fair-wage constraint: Workers are not willing to work for a wage they judge as "unfair." They conclude, that trade liberalization not only raises unemployment, but also within group wage inequality. However, in both of these papers, there is no scope for comparative advantage of countries, as they assume only one sector and one factor of production.

Helpman, Itskhoki and Redding (2008a) have many sectors and countries, and workers that differ by an exogenously given ability, which is randomly distributed. Workers are perfectly mobile between a homogenous-goods and a differentiated-goods sector. Whereas there is a perfect labor market in the former sector, the latter is subject to search-and-matching frictions on the labor market. One of their basic results is that even though trade liberalization is welfare improving, the distribution of wages becomes more unequal and the level of unemployment is higher in the trade equilibrium than in autarky. Although their model also incorporates workers with differing productivities, their approach is very different. In their model the differences among workers stem from an exogenously given distribution of ability which cannot be influenced by the workers, while in our model it is the workers themselves that invest in their human capital. This decision is endogenous and changes in response to trade liberalization. Additionally, our model features sector- and skill-specific unemployment rates which allows for a richer picture of the distributional consequences of trade liberalization. Furthermore, we have got two differentiated sectors employing both unskilled and skilled labor and in both sectors search and matching frictions occur.

The last paper we want to mention is the one by Felbermayr, Prat and Schmerer (2008) (henceforth FPS), who introduce search-and-matching unemployment into the Melitz (2003) framework, and find that trade liberalization has a positive effect on both wages and employment. As FPS rely on a model with one sector, one factor and symmetric countries, there is no scope for comparative advantages. Additionally, the effects of trade liberalization cannot be differentiated according to various skill-classes, which is at the heart of this paper.

Concerning the interaction of mobility and selection the following results of the literature are worth noting. Davidson, Martin, and Matusz (1999) assume that unemployed labor has no tie to any particular sector, since they have no sector-specific skills. This implies that the unemployed workers are mobile between sectors, allowing to apply the Stolper-Samuelson-theorem in order to evaluate the effects of trade liberalization. Hence, unemployed workers gain (loose) from trade liberalization if that particular type of labor is relatively abundant (scarce) in the country in question. The welfare effect for employed workers is driven by a weighted average of Stolper-Samuelson and Ricardo-Vinor effects. If turnover rates are high, then the Stolper-Samuelson effects dominate, while the Ricardo-Vinor effects dominate if the turnover rates are low. The implication is that, in industries with high turnover rates, employed workers gain (lose) from trade liberalization if their type of labor is relatively abundant (scarce) in their country. However, in industries with low turnover, the welfare of employed workers is tied to the overall fortunes of the sector in which they are employed (see also Davidson and Matusz (2004)).

In order to capture a worker's possibilities to switch between sectors as well as to upgrade her skills, we allow for two kinds of worker-mobility between the labor markets. First, workers may switch between the two sectors, and, second, an unskilled worker may decide to acquire sector-specific skills to become a skilled worker. In accordance with Davidson and Matusz (2004, page 10), we assume that only unemployed, unskilled workers can switch between the sectors. Typically, the acquisition of skills leads to a specialization in one sector, making it harder and much more costly to switch between sectors (see Anderson (2008)).[3] Hence, unskilled workers are less attached to sectors and therefore more mobile between the sectors. Restricting the mobility to unemployed workers seems to be realistic, as employed worker presumable has not the time and may not see the need to switch the sector. Hence, an unskilled worker can become an unemployed, skilled worker of the same sector, after paying a fixed training cost.

The main results of our model can be summarized as follows. Starting from autarky, trade liberalization leads to an increase of inter-industry trade between countries, where each country specializes in the sector where it has its comparative advantage. Comparative advantages stemming from lower training costs lead to specialization in the production of the skill-intensive good. In accordance with this specialization, workers migrate from the sector with the comparative disadvantage to the sector with the comparative advantage. Hence, skilled labor looses in the import sector and gains in the export sector, both in terms of unem-

[3]Alternatively, the jobs of skilled workers in the two sectors might be interpreted as different professions.

ployment and wages. The effects for unskilled labor are more equally distributed, because this factor is more mobil. In general, unskilled workers are worse off than skilled workers in the advantaged sector but better off than skilled workers in the disadvantaged sector. If we take an aggregate perspective, we may state that the relatively abundant factor gains more than the relatively scarce factor both in terms of real wages and employment levels, regardless of the skill-level. Further decreases in trade costs lead to intra-industry trade with different effects for unskilled workers. Increased competition in both sectors leads on average to more productive firms in both sector. In accordance with this specialization, unskilled workers migrate from the sector with the comparative disadvantage to the sector with the comparative advantage. This leads to gains for unskilled workers in both sectors, the comparative advantaged *and* disadvantaged sector, even though the gains seem modest.

The remainder of the paper is structured as follows. Section 2 outlines the theoretical model. Section 3 derives numerical results from a calibration of our model, leading to predictions on the effect of trade liberalization for all variables. Section 4 compares our results to the results with perfect labor markets and without training possibilities, i.e., with the predictions obtained from the BRS model. In section 5 we do some sensitivity analysis, in order to show the qualitative robustness of our numerical results for various plausible parameter values. The last section concludes.

2 The Model

Our model features two different factors of production (high-skilled and low-skilled labor) and two different sectors, one of them assumed to be skill-intensive. Furthermore, there is the possibility to export to a second country. Trade is subject to frictions, modeled in the type of iceberg transport costs. As in Melitz (2003) firms are heterogenous with respect to their productivity, implying that the least efficient firms drop out of the market and only the most efficient firms take up export.

The labor market is subject to search and matching frictions in the style of Mortensen and Pissarides (1999) (see also Pissarides, 2000). This means that a firm has to pay a fixed cost to post a vacancy. This vacancy will be filled with a certain probability, which depends on the tightness of the labor market, defined as the ratio of vacancies to unemployed workers. We assume that the labor markets for each sector and for each factor are separated from each other, implying that we have four different labor markets. However, we allow for mobility of workers between sectors and allow unskilled workers to grade up their skills, hence, become skilled workers.

In the following we will first describe the production process, then the labor market and finally the entry- and export decision of a firm.

2.1 Final goods

Assume that there are two countries, a home country and a foreign country, denoted H and F, respectively. In the following, we state the equations for the home country. Similar definitions apply for the foreign country. The utility of households is made up by the consumption of two goods which are produced by two different sectors, $i \in \{1,2\}$:

$$U^H = \left(C_1^H\right)^{\alpha_1} \left(C_2^H\right)^{\alpha_2}, \qquad \alpha_1 + \alpha_2 = 1, \tag{1}$$

where C_i^H is total consumption of final good i in country H, and α_i denotes the income share spend on final good i.

Both consumption goods are aggregates of intermediate goods. The production function for the aggregate goods is:[4]

$$Q_i^H = \left\{ (M^H)^{-\frac{1}{\sigma}} \int_{\omega_i^H \in \Omega_i^H} q[\omega_i^H]^{\frac{\sigma-1}{\sigma}} d\omega_i^H \right\}^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where σ denotes the elasticity of substitution between any two varieties of inputs, the measure of the set Ω_i^H is the mass M^H of available intermediate inputs in country H, each produced by a monopolistically competitive firm, and $q[\omega_i^H]$ denotes the quantity available of intermediate input ω_i^H. The normalization M^H assures that the rate of unemployment does not decrease with the size of the economy (see Blanchard and Giavazzi (2003), Egger and Kreickemeier (2008a,b) or FPS). Note that aggregate production needs not only cover aggregate consumption but also the various costs that accrue during the production process, so that $Q_i^H \leq C_i^H$.[5]

The price index corresponding to the CES-aggregated good Q_i^H is given by:

$$P_i^H = \left(\frac{1}{M^H} \int_{\omega_i^H \in \Omega_i^H} p[\omega_i^H]^{1-\sigma} d\omega_i^H \right)^{\frac{1}{1-\sigma}}, \tag{3}$$

where $p[\omega_i^H]$ is the price of a variety ω_i^H.

2.2 Intermediate Goods

Based on the utility function given in equation (1) and the consumption index given in equation (2), the inverse demand for each intermediate good can be derived as:

$$p[\omega_i^H] = q[\omega_i^H]^{-\frac{1}{\sigma}} \left(P_i^H\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_i Y^H}{M^H}\right)^{\frac{1}{\sigma}}, \tag{4}$$

[4] Whenever we use brackets this denotes arguments of functions, hence, $f[x]$ means f as a function of x.

[5] Like fixed costs of production and vacancy posting costs, which are all measured in terms of the aggregate good.

where Y^H is total income of country H.

Firms have different productivity levels $\varphi[\omega_i^H]$. As every variety of intermediate input ω_i^H is produced by one firm, we may also index firms by φ_i^H. Input producers have to pay a sunk set-up cost f in order to start production. Besides the domestic market, intermediate input producers can serve the foreign market via exports. However, entry into the export markets entails a fixed investment cost f_x. Further, serving customers abroad entails iceberg transportation costs $\tau \geq 1$. Hence, we may write the domestic and foreign inverse demand for the intermediate goods producer φ_i^H as follows:[6]

$$\begin{aligned} p_d[\varphi_i^H] &= q_d[\varphi_i^H]^{-\frac{1}{\sigma}} \left(P_i^H\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_i Y^H}{M^H}\right)^{\frac{1}{\sigma}}, \\ p_x[\varphi_i^H] &= q_x[\varphi_i^H]^{-\frac{1}{\sigma}} \left(P_i^F\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\tau \alpha_i Y^F}{M^F}\right)^{\frac{1}{\sigma}}. \end{aligned} \tag{5}$$

If a firm decides to serve domestic and foreign markets, it allocates its output so as to maximize its total revenues. Equating marginal revenues across markets yields $p_x[\varphi_i^H] = \tau p_d[\varphi_i^H]$ (see Appendix A1).

The production function of the intermediate-good producers is Cobb-Douglas:

$$q[\varphi_i^H] = \varphi_i^H S[\varphi_i^H]^{\beta_i} L[\varphi_i^H]^{1-\beta_i}, \tag{6}$$

where $L[\varphi_i^H]$ ($S[\varphi_i^H]$) is the number of unskilled (skilled) workers employed by firm φ_i^H, and β_i denotes the cost share of skilled workers.

Operating revenues of a firm in country H with productivity φ_i^H from sales on the domestic (foreign) market are equal to $R_d[\varphi_i^H] = p_d[\varphi_i^H] q_d[\varphi_i^H]$ ($R_x[\varphi_i^H] = p_x[\varphi_i^H] q_x[\varphi_i^H]/\tau$). Thus, total revenue of this intermediate input producer $R[\varphi_i^H]$ is given by:

$$\begin{aligned} R[\varphi_i^H] = {} & q_d[\varphi_i^H]^{\frac{\sigma-1}{\sigma}} \left(P_i^H\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_i Y^H}{M^H}\right)^{\frac{1}{\sigma}} \\ & + I[\varphi_i^H] q_x[\varphi_i^H]^{\frac{\sigma-1}{\sigma}} \left(P_i^F\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\tau^{1-\sigma} \alpha_i Y^F}{M^F}\right)^{\frac{1}{\sigma}}, \end{aligned} \tag{7}$$

where $I[\varphi_i^H]$ is an indicator function that takes value one when a firm in country H with productivity φ_i^H exports and zero otherwise.

2.3 Vacancy Posting

Firms are subject to labor market frictions of the matching type. They post a number of vacancies v of which only a certain share $m[\theta]$ is filled. The number of

[6] Note that $p_x[.]$ is the cif price in the foreign market and $q_x[.]$ is the quantity produced for the foreign market, including the iceberg transport costs.

matches depends negatively on labor market tightness $\theta = V/U$, where V is the total number of vacancies posted on a specific labor market and U is the number of unemployed workers on this labor market. Each period an exogenous share ρ of jobs is destroyed. Thus, the evolution of the stock of workers of a firm is governed by:

$$\begin{aligned} L_{i,t+1} &= (1-\rho)L_{i,t} + m[\theta^H_{Li}]v^H_{Li} \\ S_{i,t+1} &= (1-\rho)S_{i,t} + m[\theta^H_{Si}]v^H_{Si}. \end{aligned} \tag{8}$$

Assuming that the costs of posting a vacancy are c, and that the firm is destroyed with an exogenous probability δ, the value of a firm can then be written as:

$$\begin{aligned} J^H_{i,t} &= \frac{1}{1+r}\Big(R[\varphi^H_i] - w^H_{Li}L[\varphi^H_i] - w^H_{Si}S[\varphi^H_i] - fP^H_i \\ &\qquad -v^H_{Li}cP^H_i - v^H_{Si}cP^H_i - I[\varphi^H_i]f_xP^H_i + (1-\delta)J^H_{i,t+1}\Big), \end{aligned} \tag{9}$$

where r denotes the interest rate, and w^H_{Li} (w^H_{Si}) is the unskilled (skilled) labor wage rate in industry i in country H.

The firm maximizes its value by choosing the number of vacancies posted subject to its demand, production function and evolution of employment, i.e. equations (4), (6) and (8), respectively. The first order conditions are:

$$\begin{aligned} cP^H_i &= m[\theta^H_{Li}](1-\delta)\lambda^H_{Li,t+1}, \\ cP^H_i &= m[\theta^H_{Si}](1-\delta)\lambda^H_{Si,t+1}, \end{aligned} \tag{10}$$

where we have marginal costs on the left-hand side, marginal revenues on the right-hand side and $\lambda^H_{Li,t+1}$ ($\lambda^H_{Si,t+1}$) is the shadow value of employment of unskilled (skilled) labor in period $t+1$. These shadow values can be determined using the envelope condition. Additionally employing the steady-state condition ($J_t = J_{t+1}$), equation (10) can be written as (see Appendix A2):

$$\begin{aligned} \frac{\partial R[\varphi^H_i]}{\partial L^H_i} &= \frac{cP^H_i}{m[\theta^H_{Li}]}\frac{s+r}{1-\delta} + w^H_{Li} + \frac{\partial w^H_{Li}}{\partial L^H_i}L[\varphi^H_i], \\ \frac{\partial R[\varphi^H_i]}{\partial S^H_i} &= \frac{cP^H_i}{m[\theta^H_{Si}]}\frac{s+r}{1-\delta} + w^H_{Si} + \frac{\partial w^H_{Si}}{\partial S^H_i}S[\varphi^H_i], \end{aligned} \tag{11}$$

with $s = \rho + \delta - \rho\delta$ being the rate of job destruction.

2.4 Wages

We assume that every worker individualistically bargains with her employer. As in Stole and Zwiebel (1996) every worker is treated as the marginal worker, i.e.

as the last worker employed by the firm. The outcome of the bargaining process satisfies the following "surplus-splitting" rule:

$$
\begin{aligned}
(1-\mu)\left(E_L[\varphi_i^H]-U_{Li}^H\right) &= \mu\frac{\partial J[\varphi_i^H]}{\partial L_i^H},\\
(1-\mu)\left(E_S[\varphi_i^H]-U_{Si}^H\right) &= \mu\frac{\partial J[\varphi_i^H]}{\partial S_i^H},
\end{aligned}
\tag{12}
$$

where $E_L[\varphi_i^H]$ ($E_S[\varphi_i^H]$) denotes the asset value of an unskilled (skilled) worker employed at a firm with productivity φ_i^H in industry i, while U_{Li}^H (U_{Si}^H) is the value of an unskilled (skilled) unemployed worker. μ measures the bargaining power of a worker and belongs to $[0,1]$.

Following the same procedure as FPS we get the job-creation conditions (see Appendix A3):

$$
\begin{aligned}
w_{Li}^H &= (1-\beta)p_d[\varphi_i^H]\varphi_i^H\left(\frac{S[\varphi_i^H]}{L[\varphi_i^H]}\right)^{\beta}\frac{\sigma-1}{\sigma+\beta_i\mu-\mu-\beta_i\sigma\mu}-\frac{cP_i^H}{m[\theta_{Li}^H]}\frac{s+r}{1-\delta},\\
w_{Si}^H &= \beta p_d[\varphi_i^H]\varphi_i^H\left(\frac{S[\varphi_i^H]}{L[\varphi_i^H]}\right)^{\beta-1}\frac{\sigma-1}{\sigma-\beta_i\mu+\beta_i\sigma\mu-\sigma\mu}-\frac{cP_i^H}{m[\theta_{Si}^H]}\frac{s+r}{1-\delta}.
\end{aligned}
\tag{13}
$$

The wage curves are given by:

$$
\begin{aligned}
w_{Li}^H &= rU_{Li}^H+\frac{\mu}{1-\mu}\frac{r+s}{1-\delta}\frac{cP_i^H}{m[\theta_{Li}^H]},\\
w_{Si}^H &= rU_{Si}^H+\frac{\mu}{1-\mu}\frac{r+s}{1-\delta}\frac{cP_i^H}{m[\theta_{Si}^H]}.
\end{aligned}
\tag{14}
$$

Substituting out the value of unemployment the wage curves become:

$$
\begin{aligned}
w_{Li}^H &= b+\frac{\mu}{1-\mu}\left(\frac{r+s}{1-\delta}\frac{cP_i^H}{m[\theta_{Li}^H]}+\frac{cP_i^H\theta_{Li}^H}{1-\delta}\right),\\
w_{Si}^H &= b+\frac{\mu}{1-\mu}\left(\frac{r+s}{1-\delta}\frac{cP_i^H}{m[\theta_{Si}^H]}+\frac{cP_i^H\theta_{Si}^H}{1-\delta}\right).
\end{aligned}
\tag{15}
$$

The equilibrium on the labor market is jointly determined by the wage curve and the job-creation condition which pin down the wage and the tightness of the labor market. As in Stole and Zwiebel (1996) and FPS, the assumption that a firm is bargaining with the marginal worker implies that the wage of each worker is driven down to her outside option. This in turn implies that each firm is paying the same wage, irrespective of its productivity level. In equilibrium, each firm employs as many workers as are necessary to ensure that the marginal value of the last employed worker of the firm is equal to the wage.

2.5 Firm Entry and Exit

There is an infinite number of potential firms which can enter the market after paying a fixed and sunk entry cost f_E, measured in terms of the final consumption good of the sector the firm wants to enter. Once a firm has entered into industry i it will draw its productivity φ_i^H from a known distribution $g[\varphi_i^H]$. The productivity stays the same as long as the firm exists. Only firms which draw a φ_i^H favorable enough to make non-negative profits, will start production. To describe this entry-decision let us define the per-period profit of a firm as:

$$\begin{aligned}\pi_d[\varphi_i^H] &= p_d[\varphi_i^H]q_d[\varphi_i^H] - w_{Li}^H L[\varphi_i^H] - w_{Si}^H S[\varphi_i^H] \\ &- fP_i^H - \frac{\rho c P_i^H L[\varphi_i^H]}{m[\theta_{Li}^H]} - \frac{\rho c P_i^H S[\varphi_i^H]}{m[\theta_{Si}^H]}, \end{aligned} \tag{16}$$

which is revenue minus wage payments, fixed costs and search costs necessary to replace the fired workers.[7] A firm will decide to start up production whenever its productivity exceeds a certain threshold-value φ_i^{*H}, defined by:

$$(1-\delta)\frac{\pi_d[\varphi_{id}^{*H}]}{r+\delta} = \frac{cP_i^H L[\varphi_{id}^{*H}]}{m[\theta_{Li}^H]} + \frac{cP_i^H S[\varphi_{id}^{*H}]}{m[\theta_{Si}^H]} + fP_i^H, \tag{17}$$

where $L[\varphi_{id}^{*H}]$ and $S[\varphi_{id}^{*H}]$ are the unskilled and skilled labor inputs needed for domestic production in industry i of the firm with productivity φ_{id}^{*H}. At the beginning of its existence the firm has to "invest" in its stock of workers, i.e. all the workers have to be newly hired.[8] The discounted value of future profits has to be large enough so that a firm wants to undertake this upfront investment. Otherwise, the firm immediately exits. Equivalently to equation (17), we can determine the export threshold as:

$$(1-\delta)\frac{\pi_x[\varphi_{ix}^{*H}]}{r+\delta} = \frac{cP_i^H L[\varphi_{ix}^{*H}]}{m[\theta_{Li}^H]} + \frac{cP_i^H S[\varphi_{ix}^{*H}]}{m[\theta_{Si}^H]} + f_x P_i^H, \tag{18}$$

where $L[\varphi_{ix}^{*H}]$ and $S[\varphi_{ix}^{*H}]$ are the additional unskilled and skilled labor inputs needed to produce for the foreign market for a firm in industry i with productivity φ_{ix}^{*H}. $\pi_x[\varphi_{ix}^{*H}]$ is the additional profit from serving the export market, defined similarly as the profit from serving the local market (see equation (16)).[9] The profits from serving the foreign market have to be large enough to justify the extra fixed costs f_x. Empirical evidence strongly supports selection into export markets.[10] Hence, we focus on parameter values where only the most productive firms export and therefore $\varphi_{ix}^{*H} > \varphi_{id}^{*H}$.

[7] Remember that ρ is the separation rate and that $1/m[\theta]$ is the rate at which jobs are filled.

[8] Note that due to the linearity of adjustment costs the work-force immediately jumps to the optimal value.

[9] In Appendix A4 we derive the relationship between the zero-profit productivity cut-off and the exporting productivity cut-off.

[10] For empirical evidence on selection into the export markets, see Bernard and Jensen (1995, 1999, 2004), Roberts and Tybout (1997), and Clerides et al. (1998).

Following Melitz (2003), we define the average productivity of a domestic firm serving the domestic (foreign) market as:

$$\tilde{\varphi}_{id}^{H}[\varphi_{id}^{*H}] = \left(\frac{1}{1-G[\varphi_{id}^{*H}]}\int_{\varphi_{id}^{*H}}^{\infty}\left(\varphi_i^H\right)^{\sigma-1} g[\varphi_i^H]d\varphi_i^H\right)^{1/(\sigma-1)}, \tag{19}$$

$$\tilde{\varphi}_{ix}^{H}[\varphi_{ix}^{*H}] = \left(\frac{1}{1-G[\varphi_{ix}^{*H}]}\int_{\varphi_{ix}^{*H}}^{\infty}\left(\varphi_i^H\right)^{\sigma-1} g[\varphi_i^H]d\varphi_i^H\right)^{1/(\sigma-1)}. \tag{20}$$

Based on these definitions we can write down the free entry condition as:

$$f_E P_i^H = \left(1-G[\varphi_{id}^{*H}]\right)\left((1-\delta)\frac{\pi_d[\tilde{\varphi}_{id}^H]}{r+\delta} - \frac{cP_i^H L[\tilde{\varphi}_{id}^H]}{m[\theta_{Li}^H]} - \frac{cP_i^H S[\tilde{\varphi}_{id}^H]}{m[\theta_{Si}^H]} - fP_i^H\right)$$
$$+\left(1-G[\varphi_{ix}^{*H}]\right)\left((1-\delta)\frac{\pi_x[\tilde{\varphi}_{ix}^H]}{r+\delta} - \frac{cP_i^H L[\tilde{\varphi}_{ix}^H]}{m[\theta_{Li}^H]} - \frac{cP_i^H S[\tilde{\varphi}_{ix}^H]}{m[\theta_{Si}^H]} - f_x P_i^H\right), \tag{21}$$

where we have the costs of entering a market on the left-hand side and the expected profits on the right-hand side. The profits of the firm are not yet known at the time of the entry-decision because the productivity level is unknown. With probability $1-G[\varphi_{id}^{*H}]$ the productivity will be high enough to make production profitable. With probability $1-G[\varphi_{ix}^{*H}]$ the productivity will be high enough so that even exporting is profitable. The terms in paranthesis indicate how much a firm will earn in these cases.

Equality in equation (21) is assured by the entry of new firms. As long as average profits exceed the entry cost, new firms will enter the market, increasing competition, thereby driving down profits until they have reached the entry cost (and vice versa if profits are too low).

The ex ante probability of successful entry into industry i in country H is $\left(1-G[\varphi_{id}^{*H}]\right)$, whereas the ex ante probability of exporting conditional on successful entry is:

$$\chi_i^H = \frac{1-G[\varphi_{ix}^{*H}]}{1-G[\varphi_{id}^{*H}]}. \tag{22}$$

Given the probability of exporting, we can determine the mass of available intermediate inputs as $M^H = M_i^H + \chi_i^F M_i^F$.

2.6 Unemployment

As already mentioned above, we assume the existence of four separate labor markets: one for each sector and skill-class. Each labor market is described by a Cobb-Douglas matching function:

$$m[\theta_{Li}^H] = \bar{m}\left(\theta_{Li}^H\right)^{-\gamma},$$
$$m[\theta_{Si}^H] = \bar{m}\left(\theta_{Si}^H\right)^{-\gamma}, \tag{23}$$

where the parameter $\bar{m}$ measures the efficiency of the labor market, while γ is the elasticity of the matching function. The matching function gives the probability that a vacancy is filled in dependence of θ, the tightness of the labor market. In turn, the probability that an unskilled (skilled) worker finds a job in industry i in country H can be written as $\theta^H_{Li} m[\theta^H_{Li}]$ ($\theta^H_{Si} m[\theta^H_{Si}]$). Noting that the exogenous rate of job-destruction is given by s, the equilibrium unemployment rate is given by:

$$
\begin{aligned}
u^H_{Li} &= \frac{s}{s + \theta^H_{Li} m[\theta^H_{Li}]}, \\
u^H_{Si} &= \frac{s}{s + \theta^H_{Si} m[\theta^H_{Si}]}.
\end{aligned} \tag{24}
$$

Finally, the mass of firms has to adjust so that the labor market clears:

$$
\begin{aligned}
M^H_i \left(L[\tilde{\varphi}^H_{id}] + \chi^H_i L[\tilde{\varphi}^H_{ix}] \right) &= \left(1 - u^H_{Li} \right) \hat{L}^H_i, \\
M^H_i \left(S[\tilde{\varphi}^H_{id}] + \chi^H_i S[\tilde{\varphi}^H_{ix}] \right) &= \left(1 - u^H_{Si} \right) \hat{S}^H_i,
\end{aligned} \tag{25}
$$

where $\hat{L}^H_i$ ($\hat{S}^H_i$) is the total number of unskilled (skilled) workers in sector i in country H. The left-hand side shows the demand for labor, given by the sum of the demand of all domestic firms for domestic and export production. The right hand side of equation (25) gives the number of employed workers (from the supply-side). Note that the total number of people in country H is determined by $N^H = \sum_i \left(\hat{L}^H_i + \hat{S}^H_i \right)$.

2.7 Mobility

We allow for two kinds of worker-mobility between the labor markets. On the one hand a worker might want to switch between the two sectors, on the other hand an unskilled worker might want to train to become a skilled worker.

Considering the movement between the sectors we assume that only unemployed, unskilled workers can switch between the sectors. Typically, the acquisition of skills implies a specialization in one field, which clearly restricts the mobility between one sector and the other. On the other hand, unskilled workers are much less specialized and thus more mobile between the sectors. Furthermore, an employed worker is not likely to have the time and, maybe even more importantly, does not see the need to switch the sector. Therefore, we restrict the mobility between sectors to unemployed, unskilled workers. All this is in line with the reasoning of Davidson and Matusz (2004, page 10).

We assume that in the long-run there are no mobility costs between the two sectors. Hence the value of an unskilled, unemployed worker in both sectors needs to be equalized in the home as well as in the foreign country:

$$
\begin{aligned}
U^H_{L1} &= U^H_{L2}, \\
U^F_{L1} &= U^F_{L2}.
\end{aligned} \tag{26}
$$

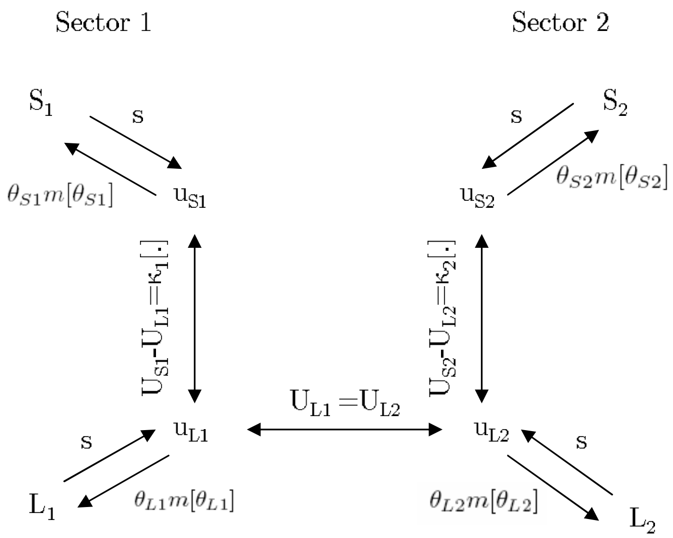

Figure 1: Mobility Assumptions of Workers

For the same reasoning as above, we assume that only an unemployed worker has the time and motivation to invest in her human capital. After paying a fixed training cost an unemployed, unskilled worker can become an unemployed, skilled worker in the same sector. To get an interior solution we assume that workers are heterogenous with respect to training costs. Since the workers with the highest training ability will train first, this implies that training costs are increasing in the number of skilled workers. For simplicity we assume a linear relationship, hence training costs are given by:

$$\begin{aligned} \kappa[\hat{S}_i^H] &= \bar{\kappa}^H \hat{S}_i^H, \\ \kappa[\hat{S}_i^F] &= \bar{\kappa}^F \hat{S}_i^F, \end{aligned} \tag{27}$$

where $\bar{\kappa}^H$ $(\bar{\kappa}^F)$ are country specific constants, implying $\partial\kappa[\hat{S}_i^H]/\partial\hat{S}_i^H > 0$ as well as $\partial\kappa[\hat{S}_i^F]/\partial\hat{S}_i^F > 0$.[11]

Then the number of skilled worker is endogenously determined by:

$$\begin{aligned} U_{Si}^H - U_{Li}^H &= \kappa[\hat{S}_i^H], \\ U_{Si}^F - U_{Li}^F &= \kappa[\hat{S}_i^F]. \end{aligned} \tag{28}$$

The marginal worker in country H (F) is just indifferent between training and staying unskilled because the gain from training, $U_{Si}^H - U_{Li}^H$ $(U_{Si}^F - U_{Li}^F)$, is exactly equal to the costs of training, $\kappa[\hat{S}_i^H]$ $(\kappa[\hat{S}_i^F])$.

Figure 1 summarizes our structure concerning the mobility of workers and gives the indifference conditions for unemployed, unskilled workers to switch sectors, as well as for unemployed, unskilled workers to invest in her human capital.

[11] $\bar{\kappa}^H$ $(\bar{\kappa}^F)$ are used to calibrate the shares of skilled workers in the home (foreign) country.

It also illustrates the four separate labor markets and the flows on these markets between unemployment and employment.

3 Numerical Results

3.1 Calibration

In order to highlight the interaction of comparative advantages and the endogenous selection of workers to sectors and skill classes, we assume that sector one is skill intensive relative to sector two in both countries ($\beta_1 = 0.8$ and $\beta_2 = 0.2$) and that consumers in both countries spend a larger share of their income on final goods of sector one ($\alpha = 0.7$). Further, country one is assumed to have better training opportunities, i.e. $\bar{\kappa}_i^H < \bar{\kappa}_i^F$. Specifically, we choose the training costs such that the country with better training opportunities has 50% skilled workers, while the other country has only 20% skilled workers. This is in line with data from the OECD (2007), showing that the share of the population attaining the tertiary level of education can range from 54% for Canada to 20% for Slovenia.[12]

The model is calibrated for moderate trade costs $\tau = 1.3$. The elasticity of substitution σ is set to 3.8. Concerning the ex ante firm productivity we assume a Pareto distribution, given by:

$$g[\varphi_i^H] = ak^a \left(\varphi_i^H\right)^{-(a+1)}, \tag{29}$$

where k is the minimum value of productivity ($\varphi_i^H \geq k$), and $a > 0$ is the shape parameter that determines the skewness of the Pareto distribution. We set $k = 0.2$ and $a = 3.4$ for both countries and both industries. Both values are the same as in BRS and FPS. As BRS we choose fixed entry costs and fixed productions cost to be $f_E = 2$ and $f = 0.1$. The fixed costs of serving the foreign market are set to $f_x = 0.193$. This implies that approximately 22% of firms in sector one of country one export, which is in line with Bernard, Eaton, Jensen and Kortum (2003).

The probability of firm-breakdown is set equal to $\delta = 0.11$, implying an annual gross rate of firm turnover of 22% as suggested by Bartelsmann, Haltiwanger and Scarpetta (2004). Based on the estimates of Shimer (2005) we choose the annual rate of job separation to be 0.41. This implies that the rate of firm-specific shocks is equal to $\rho = 0.3$.

Following Petrongolo and Pissarides (2001) the elasticity of the matching function is set equal to 0.5. While Hall (2005) finds a labor market tightness of 0.5, Shimer (2005) gets a monthly job-finding rate of 0.45. From equation (23) it

[12] In the sensitivity analysis we show that choosing more equal countries does not change the qualitative results of the model. Note, that we calibrate the model for unskilled labor in sector one and country one. We then use the same parameters for all other markets, except for the differences just noted.

follows that the monthly job-filling rate has to be 0.9, which in turn implies an efficiency parameter for the matching function of $\bar{m} = 7.6$.

We set the discount rate to $r = 0.04$, implying a yearly interest rate of 4%. The replacement rate of unemployment benefits, b, is equal to 0.4, which implies that workers receive 40% of their wage when becoming unemployed. Both values are well in line with empirical facts and similar to BRS and FPS. Considering the parameter for the bargaining power of workers, we follow the common practice and set it equal to the elasticity of the matching function. Specifically, we set $\mu = 0.5$. The equality of the bargaining power and matching function elasticity is known as the "Hosios condition" (Hosios, 1990). Note, however, that in the present model this condition is not sufficient to ensure an efficient allocation due the over-hiring externality (see also Felbermayr, Prat, and Schmerer (2008)).[13] Finally, we choose the costs of posting a vacancy such that the resulting labor market tightness for unskilled workers in sector one matches the value of 0.5 (see Hall (2005) for empirical evidence). This implies a value of $c = 0.134$.

3.2 The Effects of Trade Liberalization

In this section we illustrate the effects of trade liberalization for our baseline economy. We start out with a τ equal to 5 - which implies that there is almost no trade at all - and lower it until it reaches 1, implying free trade. The most important effects of trade liberalization are summarized in the form of results.

Due to the differences in training costs between the countries, even under autarky the two countries do not produce the same sectoral mix of products. Lower training costs imply that it pays of for more workers to acquire the skills necessary to perform a skilled labor job. This leads to an abundance of skilled workers in the country with lower training costs. Hence, even in autarky country one produces more of goods in sector one, whereas country two produces more of goods in sector two.

In the following we concentrate on the characterization of the skill-abundant country, country one. Under very high trade costs, unskilled labor, which is the more mobile factor, has higher unemployment in sector one. This might seem a bit surprising, given that country one produces more in sector one, but it is explained by the fact that the higher wage in sector one attracts many workers to this sector. For the less mobile factor, skilled labor, things look a bit different. This factor is generally better off in the sector with the comparative advantage.

Result 1 ***[Specialization]:***
As trade costs decrease, inter-industry trade increases and each country specializes in the sector where it has its comparative advantage, i.e. the country with lower

[13]We take care in all our simulations that the condition given in Appendix A5 is satisfied. In the sensitivity analysis we demonstrate that this does not affect our qualitative results.

Table 1: Calibration of Parameters Values

Parameter	Description	Value	Source
r	Discount rate	0.04	4% annual discount rate
σ	Elasticity of Substitution	3.8	BRS
β_1	Skilled labor cost share in sector one	0.8	Similar to BRS
β_2	Skilled labor cost share in sector two	0.2	Similar to BRS
α	Industry one goods income share	0.7	Reflects higher income share sector
f_E	Fixed entry cost	2	BRS
f	Fixed cost of production	0.1	BRS
f_x	Fixed foreign market access costs	0.193	Bernard, Eaton, Jensen and Kortum (2003)
δ	Rate of firm exit	0.11	Bartelsmann, Haltiwanger and Scarpetta (2004)
k	Minimum value of productivity	0.2	BRS
a	Shape of Pareto Distribution	3.4	BRS
b	Unemployment benefits	$0.4\times$ wage	40% effective replacement rate
μ	Bargaining power	0.5	Hosios (1990)
γ	Elasticity of matching function	0.5	Petrongolo and Pissarides (2001)
$\bar{m}$	Efficiency of matching function	7.6	Shimer (2005) and Hall (2005)
c	Cost of posting a vacancy	0.134	To match $\theta = 0.5$ (Hall, 2005)
ρ	Monthly job separation rate	0.3	Shimer (2005)
$\bar{k}_i^H$	Training costs in country H	$0.0105 \times P_i^H$	Implies 50% skilled workers
$\bar{k}_i^F$	Training costs in country F	$0.076 \times P_i^F$	Implies 20% skilled workers
τ	Iceberg trade costs	1.3	Ghironi & Melitz (2005)
$N^H = N^F$	Size of population	1000	Size normalization
P_1^H	Numéraire	1	Normalization

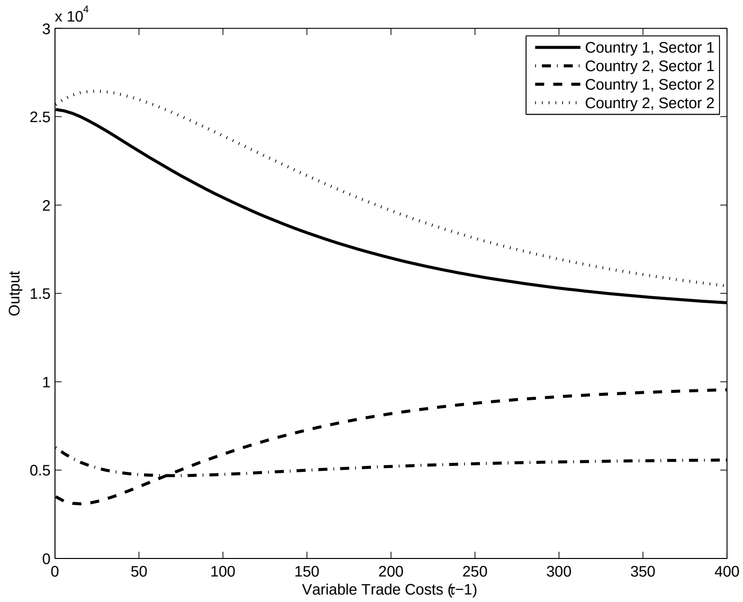

Figure 2: Production per Sector

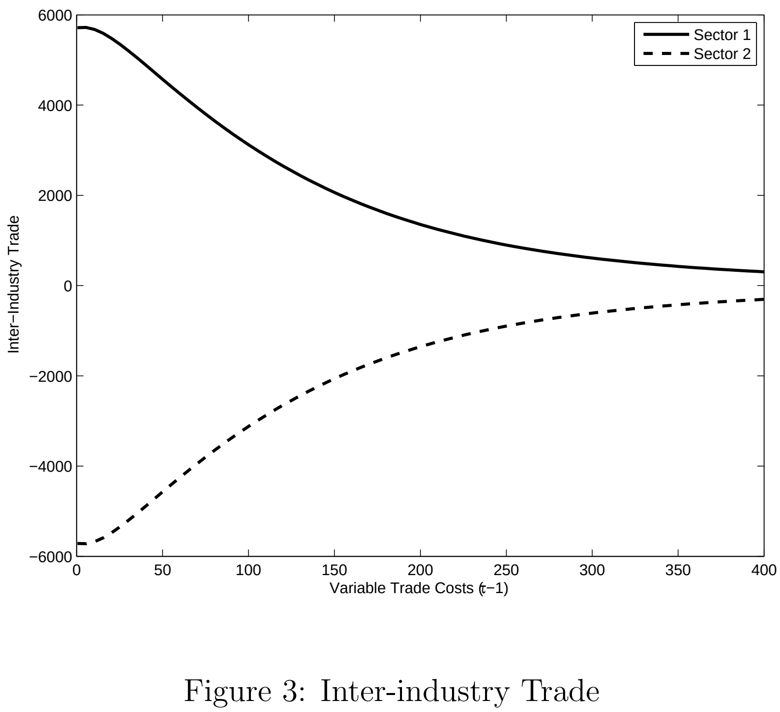

Figure 3: Inter-industry Trade

training costs specializes in the production of the skill-intensive good and vice versa.

Let us study the effects of trade liberalization on the most important variables in turn. Going from right to left in Figure 2, we see that each country specializes increasingly in the sector with its comparative advantage. Hence, lower trade costs lead to stronger specialization in the production structure. Specifically, country one increases production in sector one and decreases production in sector two. At the same time country one becomes a net-exporter of goods from sector one and a net-importer of goods from sector two. Inter-industry trade increases considerably when trade costs are lowered (see Figure 3).[14]

The increased specialization of countries is possible because trade costs are lower, which makes it easier to exchange goods between countries. This induces, as in the traditional Heckscher-Ohlin model, reallocation of workers between sectors. However, additionally to this traditional reallocation of workers, our model allows for an endogenous response in the composition of the skills of the workforce.

Result 2 ***[Worker Mobility]:***

- *As a country specializes in one industry, workers migrate from the sector with the comparative disadvantage to the sector with the comparative advantage.*
- *As trade costs decrease, the share of skilled workers increases in both countries.*

The findings of Result 2 are illustrated in Figures 4 and 5. As the activity in the economy shifts from one sector to the other this has two distinct effects on the decisions of workers. On the one hand, unskilled workers move from the disadvantaged sector to the advantaged sector. On the other hand, workers in the disadvantaged sector find it less profitable to invest in their human capital and the number of skilled workers in this sector decreases. It turns out that the increase of skilled workers in the advantaged sector outweighs the decrease in the disadvantaged sector and so the total share of skilled workers increases.

Note that even in the country abundantly endowed with low-skilled workers the share of skilled workers increases when trade costs fall. The reason behind this increase is the same as for the country abundantly endowed with high-skilled

[14]The reader might have noticed that specialization and inter-industry trade do not increase for the whole range of trade costs. Rather, both reach a peak when trade costs are very small. The reason for the decrease of inter-industry trade and specialization in the production structure lies in the increased importance of intra-industry trade for very low trade costs. We will explain this in more detail further below.

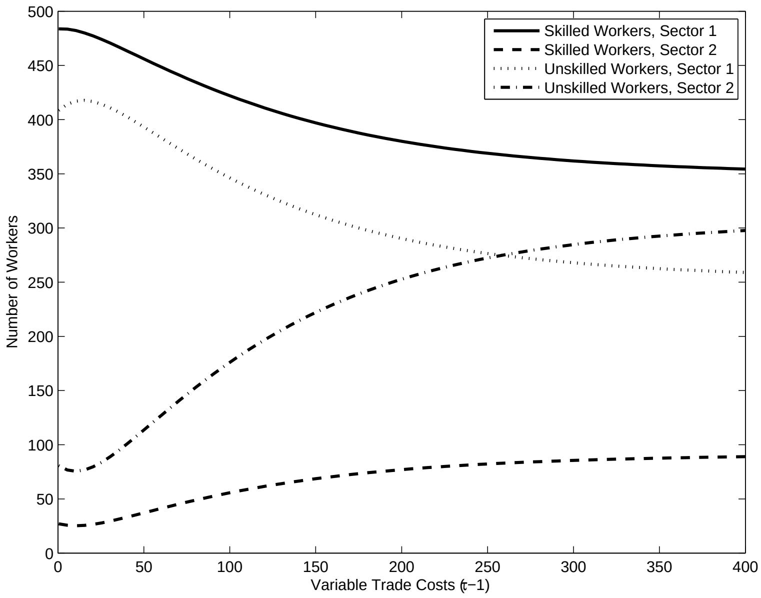

Figure 4: Workers per Sector

labor: The increased demand in the unskilled labor intensive sector two makes training in this sector more profitable. Hence, the number of skilled workers in this sector increases. This increase dominates the decrease of skilled workers in sector one, leading to an overall increase in the number of skilled workers.

Let us now turn to the distributional consequences of trade liberalization. As we have two skill-groups and two different sectors, this allows us to differentiate the trade liberalization effects for each skill-group in every sector.

Result 3 ***[Disaggregate Labor Market Effects]:***

- *For skilled labor (the less mobile factor) the gains from trade are very unequally distributed, with workers in the disadvantaged sector loosing and workers in the advantaged sector gaining a lot.*
- *For unskilled labor (the more mobile factor) the effects are more equally distributed. In general, unskilled workers are worse off than skilled workers in the advantaged sector but better off than skilled workers in the disadvantaged sector.*

The result is best understood by looking at Figures 7 and 8 showing unemployment and real wages for both sectors in country one. From these figures we can see that skilled labor - the relatively abundant factor - is gaining tremendously in sector one while it is loosing in sector two - both in terms of wages and

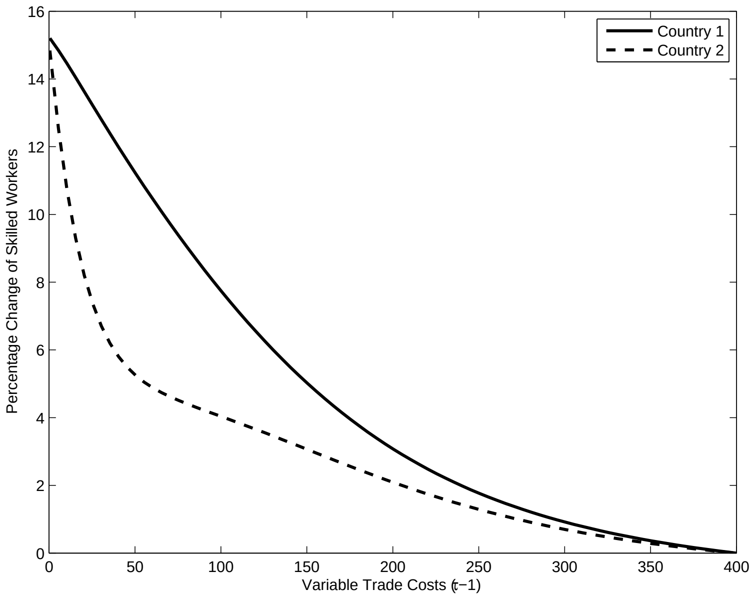

Figure 5: Share of Skilled Workers

unemployment: In sector one, the wage of skilled labor increases and the unemployment rate decreases, while in sector two, wages decrease and unemployment increases. Thus for skilled labor, the immobile factor, our model is clearly in line with the predictions of Ricardo-Viner. The factor tied to the export industry gains, while the factor tied to the import industry looses.

From Figures 7 and 8 it becomes also clear that the effects for unskilled labor are much more equally distributed. In fact they have to be, because differences in the wage lead to the immediate migration of workers from one sector to the other. This migration leads to a surprising result: The movement of workers to the export-sector increases the labor supply in this sector to such an extent that unemployment increases while it decreases in the import-sector.

In all the figures we have seen so far, there is a markable change in effects once trade costs have become very small: The specialization of production is overturned, the unemployment rates for all factors and all sectors are dropping and all wages are increasing. All this is explained by the rising importance of intra-industry trade in sector two.

Result 4 ***[Intra-industry trade]:***
Intra-industry trade improves productivity in the disadvantaged sector and thereby counteracts the effects of inter-industry trade.

As long as trade costs are relatively high, trade is about exploiting productivity differences - the skill abundant country exports the skill-intensive good and

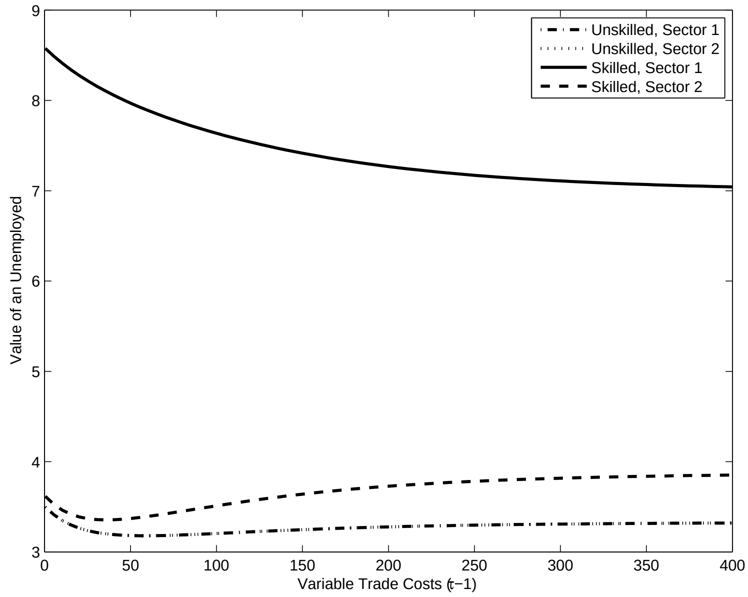

Figure 6: Value of Unemployed Workers

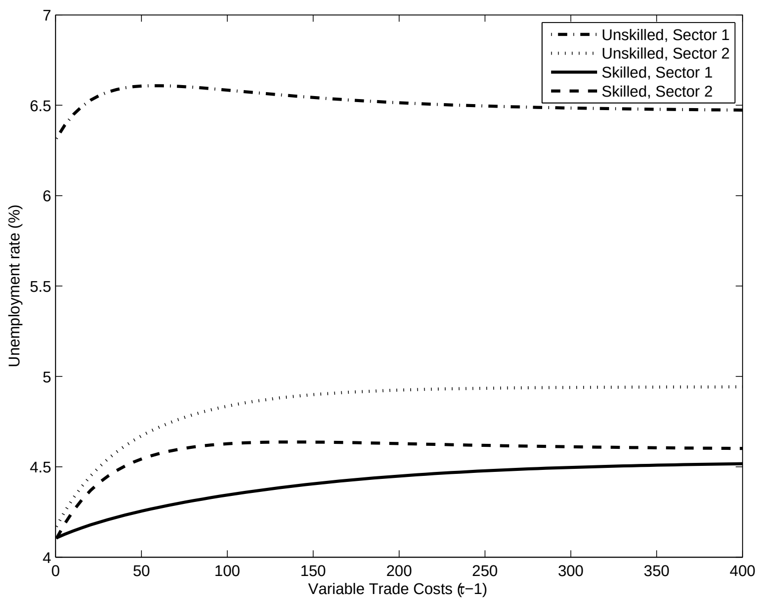

Figure 7: Unemployment

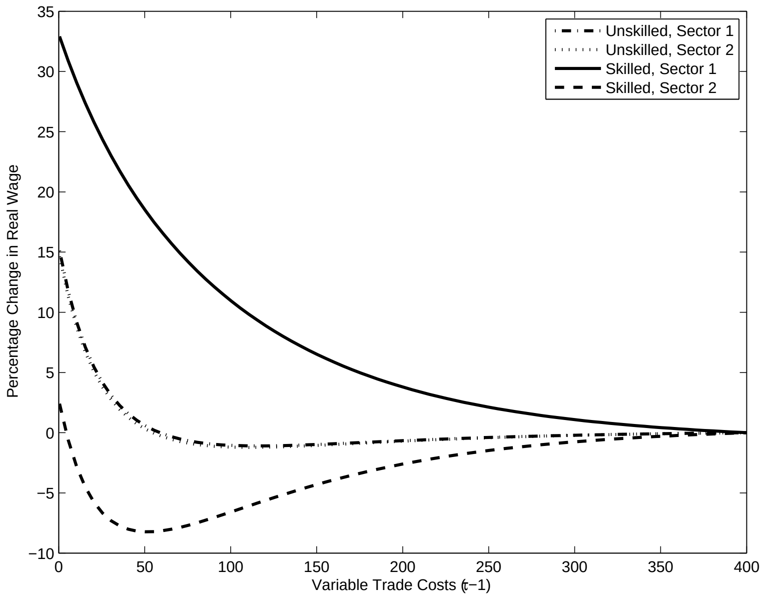

Figure 8: Real Wages

vice versa. However, once trade costs have become sufficiently low, love for variety becomes more and more important. Consumers generally value the slightly different varieties from the foreign country but for high trade costs these differences are not worth exploiting. However, this changes once trade costs are sufficiently low, implying that country two's demand for sector-two-goods from country one rises. Although country two can produce these goods relatively cheaper than country one, the differing varieties imply that country two will start exporting them, too.

This increase in exports in sector two has a big impact on competition in this sector. While the unproductive firms were well protected as long as trade was concentrated in sector one, they are now driven out of the market. This increases average productivity in the sector, raises wages and thus makes the sector more attractive to workers. This effect weakens the aforementioned specialization trend and can even overturn it when trade costs become sufficiently low. The importance of intra-industry trade is best illustrated in Figure 9, showing the share of intra-industry trade in total production in the respective sector. While mainly negligible for relatively high trade costs, there is a sharp increase in intra-industry trade once trade costs drop below 100%.

So far we have concentrated on the effects of trade liberalization in each of the two sectors separately. However, in the public debate the focus is very often on the whole population of unskilled versus skilled workers. The following result deals with this aspect.

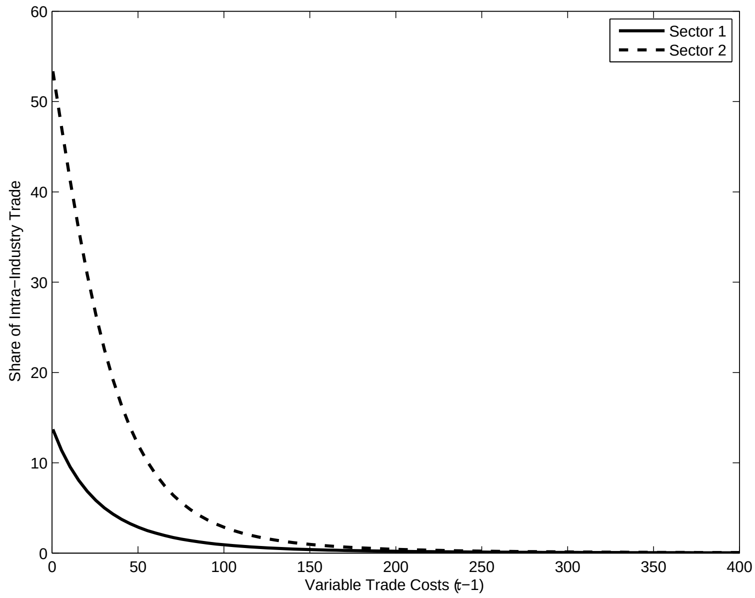

Figure 9: Intra-Industry Trade

Result 5 ***[Aggregate Labor Market Effects]:***
The relatively abundant factor gains more than the relatively scarce factor, both in terms of real wages and employment levels.

In Figure 10 we have aggregated the two sectors into averages of the whole population. For ease of interpretation, the graph is normalized by using the respective values under autarky. Hence, the graphs show the relative changes as compared to the situation under autarky.

As can be seen from the figures, skilled labor, used intensively in the sector country one specializes in, gains, whereas the effects for unskilled labor are ambiguous. Unskilled labor looses from trade liberalization if we start out with high values of trade costs. However, once trade barriers are very small, even unskilled labor gains from further decreases in trade costs.[15] The initial losses in income are very small and can therefore be compensated by the later gains. Hence under completely free trade the incomes of low-skilled workers will be higher than under autarky. However, the picture for unemployment looks a bit different. The increase in unemployment is substantial and reaches up to 10%. The improvements for very low trade costs are not sufficient to make up for the initial increases and so even for zero trade costs the unemployment rate is higher than under autarky.

[15]It should be noted that the result that unskilled labor looses from trade liberalization for high values of trade costs is sensitive to the calibration of the model. However, the result that skilled labor in country one gains more from trade liberalization is robust. For more details see the section on sensitivity analysis.

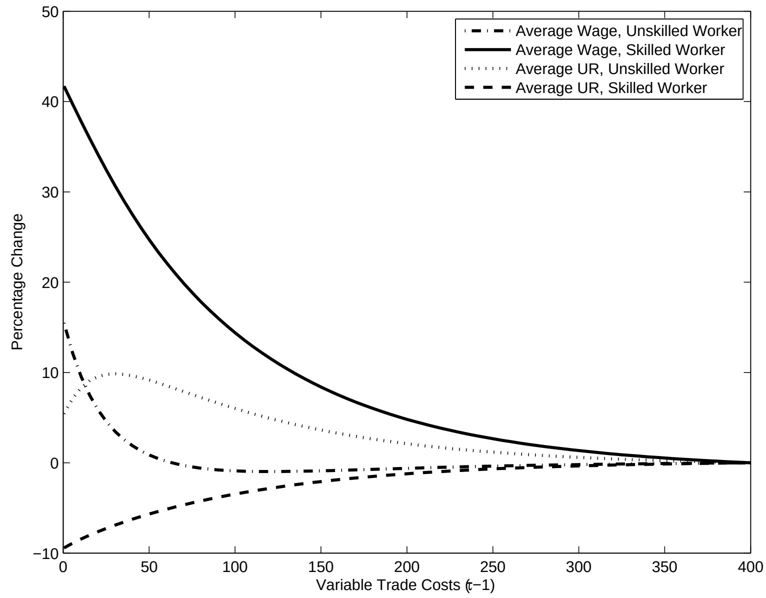

Figure 10: Average Unemployment and Average Wages

One distinguishing feature of our model compared to other recent models dealing with trade liberalization effects on unemployment (see for example Egger and Kreickemeier (2008a,b), Helpman, Itskhoki and Redding (2008a,b), and FPS) is the possibility to study the role of comparative advantages. To highlight the importance of comparative advantages, we run our simulations for different values of training costs, which is the source of comparative advantages in our model. Specifically, we set the training costs of country two to the same value as for country one in the baseline calibration, i.e. $\bar{k}_i^H = 0.0105 \times P_i^H$ and $\bar{k}_i^F = 0.0105 \times P_i^F$, leaving all other parameters unchanged. Then we increase the training costs of country two step by step to the value of our baseline calibration ($\bar{k}_i^F = 0.076 \times P_i^F$). We then investigate how the effects of trade liberalization are changed by the weakening of the comparative advantages. To summarize our results, we compare the average wage and the average unemployment under autarky with the situation in free trade. Hence, we calculate the percentage change that results from a switch from autarky to free trade for different values of training costs. The results for country one are illustrated in Figure 11.

Result 6 ***[Comparative Advantage]:***
The relatively abundant (scarce) factor is better off (worse off) if comparative advantages become stronger. Stronger comparative advantages even can change the sign of the effects for unskilled labor concerning unemployment.

Starting from the left to the right, it gets relatively easier to train to become a skilled worker. Hence, country one gets more and more skill abundant, leading

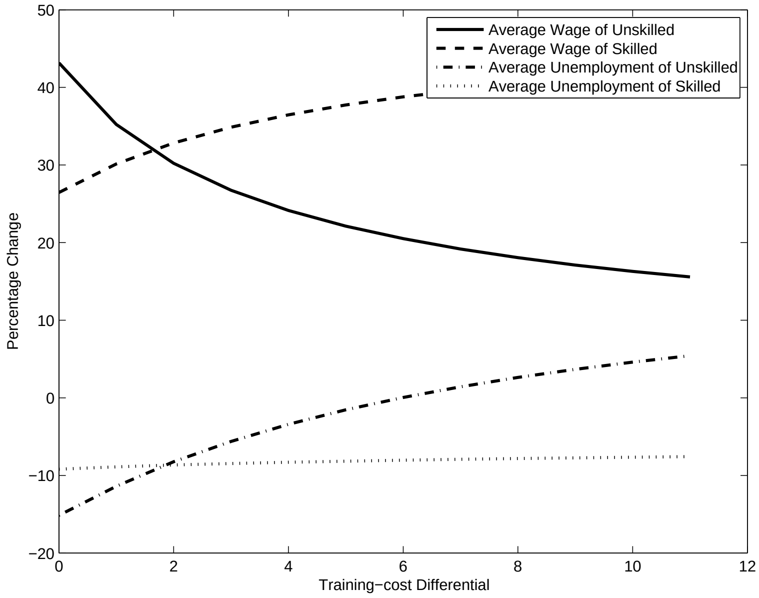

Figure 11: The Effects of Trade Liberalization and Comparative Advantage

to a comparative advantage in producing good one. The increasing comparative advantage is good news for skilled labor but not for unskilled labor. While unskilled labor is profiting much more from trade liberalization if there is no comparative advantage (see the very left end of the figure), the picture changes completely if the comparative advantage becomes important (at the right end of the figure). Most remarkable are the effects for unemployment. Without comparative advantage, trade liberalization reduces the average unemployment rate of unskilled workers by 15%. However, this effect becomes smaller for higher degrees of comparative advantage and in the end unemployment even increases. For skilled labor things are very different. While the unemployment rate is almost unaffected, the wage increases are much larger if the comparative advantage is strong.

These results may give a theoretical foundation for the large protests of many people against further trade liberalization. This protest against trade integration should be larger when it comes to the integration of less developed countries, and should stem mainly from people with lower levels of education. This is for example documented in the joint full report of Eurobarometer 61 and CC Eurobarometer 2004.1.[16] It states at page B.3: "Overall, in the Union, young people and the most educated are more inclined to view globalisation as a positive phenomenon for their country." In the Flash EB 132/2[17] on page 31 the answers to the question

[16]Publicly available at http://ec.europa.eu/public_opinion/cceb_en.htm.
[17]Publicly available at http://ec.europa.eu/public_opinion/flash/fl132_2_en.pdf.

“Are you, personally, in favour, of the European Union enlargement?” it says: “It appears that the longer one spent studying, the more one is in favour of the enlargment.”

4 Comparison to Bernard, Redding and Schott

As we have seen in the last section, comparative advantages are at the heart if one wants to understand the fears and the distributional consequences of globalization. However, recent work investigating the distributional consequences and allowing for unemployment do not allow for comparative advantages due to factor endowment differences (see for example Egger and Kreickemeier (2008a,b), Helpman, Itskhoki and Redding (2008a,b), and FPS). BRS is one notable exception that allows for factor endowment driven comparative advantages in a model with heterogenous firms. Hence, we want to compare our results with the predictions of the model of BRS.

In comparing the results, we first have to note that BRS assume a Walrasian labor market. Hence, there is no scope to study the effects of trade liberalization for unemployment. Remembering the quote at the beginning, unemployment seems to be at the focus of public interest when it comes to the evaluation of trade liberalization. Our model is capable of analyzing unemployment rates, and the results are shown in Figure 7. Further, we can investigate the impact of trade liberalization on the welfare of unemployed workers, as is shown in Figure 6.

Both models, the model of BRS and our suggested model, predict real wage changes for unskilled and skilled labor in the pace of trade liberalization. Due to our assumption of separate labor markets, training possibilities of unskilled workers, and unemployment, our model does not lead to equalization of real wages across sectors. However, in the model of BRS, following the Heckscher-Ohlin assumption of perfect labor mobility between sectors, real unskilled and skilled labor wages between sectors are equalized. Figure 12 shows the changes of real wages of trade liberalization starting from autarky. Note, that we distinguish between unskilled and skilled workers and sectors. The main difference lies in the fate of skilled workers which (in our suggested model) depends heavily on the sector where they are employed. Real wages of skilled workers in the export sector rise, while real wages of skilled workers in the import sector fall. The reason is that the export sector expands, which is the skill-intensive sector in country one. In the model of BRS the real wages of skilled workers increase heavily in both sectors. The reason is that country one specializes in sector one, the skilled-labor intensive sector, leading to a shift of workers form sector two to sector one. As workers are perfectly mobile, this reallocation takes place as long as wage differentials between sectors exist.

Actually, the shift of workers necessary to equalize wages between sectors in the model of BRS has consequences for several predictions. Most notably is the

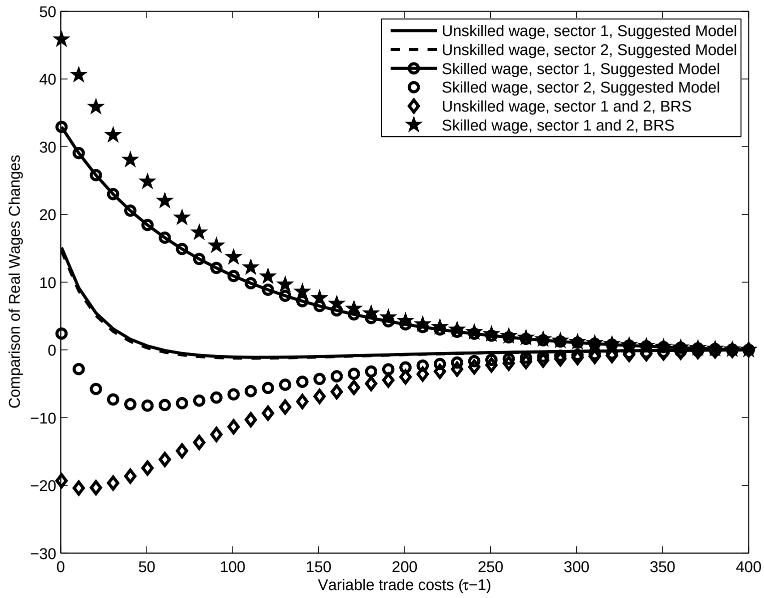

Figure 12: Comparison of Real Wages

large increase in both, inter- and intra-industry trade. Whereas inter-industry trade is predicted to be 2.5-times larger in free trade in the model of BRS as compared to our suggested model, intra-industry trade in sector one (two) is even predicted 3-times (3.5-times) larger than in our results.

Empirically it is well known that the Heckscher-Ohlin model performs poorly (see for an overview Feenstra, 2004, chapter 2). One of the shortcomings is that implied factor services trade is much smaller than the factor-endowments predictions. This phenomenon is called the "the case of the missing trade" (Trefler, 1995). As trade volume predictions in our model are much smaller than the ones form the BRS model based on the Heckscher-Ohlin framework, considering separated labor markets and introducing unemployment may provide empirical guidelines along which the puzzle of the "missing trade" may be solved.[18]

5 Sensitivity Analysis

In this section we want to the analyze the qualitative and quantitative impact of various parameters on the results illustrated above. For brevity, we do not include figures in this section. However, all the figures underlying the analysis are available as a supplement to the paper. As in the BRS- and the Heckscher-Ohlin-

[18]These are by no means the only possibilities to solve the "missing trade" puzzle. Technological differences are the prime candidate to make the Heckscher-Ohlin predictions fit the data and where investigated heavily in the literature (see Feenstra, 2004).

model and as already discussed above, our main results are driven by comparative advantages between countries. In our case these comparative advantages stem from differing training technologies. A country which offers its worker better training possibilities will have more skilled workers and thus a comparative advantage in the production of skill-intensive goods. It was demonstrated that in such a setup trade liberalization will benefit skilled workers, reducing their unemployment rates and increasing their wages.

It was also shown that decreasing the role of comparative advantage by lowering the differences in training costs has important implications for the outcome of the model. Thus it is not very surprising that other parameters, affecting the importance of comparative advantage have similar consequences. These parameters are the share of skilled workers in production β and the importance of the skill-intensive good in the utility-function, α.

In our baseline calibration we assumed that sector one is skill-intensive with $\beta_1 = 0.8$ and that the other sector produces with $\beta_2 = 0.2$. Reducing the difference in the β's by lowering β_1 and simultaneously increasing β_2 decreases the importance of comparative advantages because the production technologies of both sectors become more similar. For skilled labor this has no qualitative effect. Quantitatively the impact of trade liberalization is somewhat smaller, but skilled labor is still gaining unambiguously. To the contrary, the losses of unskilled labor become smaller with the decreasing difference in the β's and can even be overturned into gains. For the constellation $\beta_1 = 0.6$ and $\beta_2 = 0.4$ unskilled labor is, as skilled labor, unambiguously gaining from trade liberalization, although the gains are still smaller than the gains for skilled labor.

Very similar are the effects for a decrease of the importance of the skill-intensive good in the utility function α. Again the results for skilled labor are only quantitatively affected, but not qualitatively, while for unskilled labor the losses in wages can be overturned to wage-increases. However, trade liberalization initially still increases unemployment of unskilled workers. This increase is lowered by decreasing the value of α but even for $\alpha = 0.5$ unemployment rises with beginning trade liberalization and only falls for very low trade costs and the onset of intra-industry trade (as in our baseline calibration).

Other key parameters of the model, like the elasticity of substitution σ, the bargaining power of workers μ and the replacement rate of unemployment benefits b, only have quantitative impacts on the level of unemployment. However, the result that trade liberalization initially harms unskilled workers still holds.

6 Conclusions

The question how gains from trade are distributed has a long history in international trade. As long as the history is, as diverse are the answers. Two of the most prominent international trade models, the Heckscher-Ohlin model and the Ricardo-Viner model, for example, lead to very different predictions regarding the distributions of trade gains. One of the keys to understand these differences is to consider the different possibilities to react to changes in the economic environment: Whereas factors are perfectly mobile between sectors in the Heckscher-Ohlin model, the Ricardo-Viner model assumes factors that are specific to sectors.

As the possibilities to switch sectors as well as to train oneself seems to be an important mechanism to respond to trade liberalization, one of our main contributions is to incorporate an endogenous selection of people to sectors and skill-classes. Specifically, we propose a model with two factors, two sectors, search and matching unemployment and endogenous worker flows. Further we allow for heterogeneous firms with varying productivities, which copes with the most recent empirical findings of varying firm sizes and export status.

We show that trade liberalization can have very diverse effects for the different skill classes. As trade costs decrease, a country with a relative advantage in the training technology will specialize in the production of the skill intensive good. Workers will migrate to this sector and invest more in their human capital.

The big winners are the skilled workers in the export sector, while skilled workers in the import sector loose. In this respect our model replicates the result of the famous Ricardo-Viner model, which argues that the fate of an immobile factor will be linked to the fate of the sector where it is employed. Thus, a factor linked to the export sector will loose, while a factor linked to the import sector will gain.

On the other hand, the effects for unskilled labor (the more mobile factor) are much more equally distributed. In line with the Heckscher-Ohlin model, in the country exporting the skill-intensive good, unskilled labor will suffer losses: Unemployment goes up and wages go down. Only for very low trade costs, intra-industry trade can overturn this result.

These results may help to explain why specifically people with low education levels in developed countries fear opening the borders to less developed countries, whereas higher educated people are generally more in favor of globalization. Furthermore, our trade volume predictions are much lower than the ones from comparable models without separated labor markets and unemployment. Hence, considering disintegrated labor markets and unemployment may be fruitful to shed further light on the "case of the missing trade".

Appendix

A1 Derivation of Equation (7) and Equalization of Marginal Revenues

To show that $p_x[\varphi_i^H] = \tau p_d[\varphi_i^H]$, we proceed as follows. First, according to equation (4):

$$p_d[\varphi_i^H] = q_d[\varphi_i^H]^{-\frac{1}{\sigma}} \left(P_i^H\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_i Y^H}{M^H}\right)^{\frac{1}{\sigma}}, \tag{A1}$$

$$p_x[\varphi_i^H] = q_x[\varphi_i^H]^{-\frac{1}{\sigma}} \left(P_i^F\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\tau\alpha_i Y^F}{M^F}\right)^{\frac{1}{\sigma}}. \tag{A2}$$

Hence, revenues on the domestic and foreign market are given by:

$$R_d[\varphi_i^H] = q_d[\varphi_i^H]^{\frac{\sigma-1}{\sigma}} \left(P_i^H\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_i Y^H}{M^H}\right)^{\frac{1}{\sigma}}, \tag{A3}$$

$$R_x[\varphi_i^H] = q_x[\varphi_i^H]^{\frac{\sigma-1}{\sigma}} \left(P_i^F\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\tau^{1-\sigma}\alpha_i Y^F}{M^F}\right)^{\frac{1}{\sigma}}. \tag{A4}$$

Now taking partial derivatives with respect to L_i^H and using equation (6) leads to:

$$\frac{\partial R_d[\varphi_i^H]}{\partial L_{id}^H} = \frac{\sigma-1}{\sigma} q_d[\varphi_i^H]^{-\frac{1}{\sigma}} \left(P_i^H\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_i Y^H}{M^H}\right)^{\frac{1}{\sigma}} \varphi_i^H (1-\beta_i) \left(\frac{S_d[\varphi_i^H]}{L_d[\varphi_i^H]}\right)^{\beta_i},$$

$$\frac{\partial R_x[\varphi_i^H]}{L_{ix}^H} = \frac{\sigma-1}{\sigma} q_x[\varphi_i^H]^{-\frac{1}{\sigma}} \left(P_i^F\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\tau^{1-\sigma}\alpha_i Y^F}{M^F}\right)^{\frac{1}{\sigma}} \varphi_i^H (1-\beta_i) \left(\frac{S_x[\varphi_i^H]}{L_x[\varphi_i^H]}\right)^{\beta_i},$$

where $L_d[\varphi_i^H]$ ($L_x[\varphi_i^H]$) denotes unskilled labor inputs for domestic (foreign) production of a firm in industry i in country H with productivity φ_i^H. Similarly, $S_d[\varphi_i^H]$ ($S_x[\varphi_i^H]$) denotes skilled labor inputs for domestic (foreign) production of a firm in industry i in country H with productivity φ_i^H.

Noting that we assume a Cobb-Douglas production function which is linear homogeneous, the ratios $S_d[\varphi_i^H]/L_d[\varphi_i^H]$ and $S_x[\varphi_i^H]/L_x[\varphi_i^H]$ are equal. Hence, we can reformulate as follows:

$$\frac{\partial R_d[\varphi_i^H]}{\partial L_{id}^H} = \frac{\sigma-1}{\sigma} p_d[\varphi_i^H](1-\beta_i) \left(\frac{S_d[\varphi_i^H]}{L_d[\varphi_i^H]}\right)^{\beta_i}, \tag{A5}$$

$$\frac{\partial R_x[\varphi_i^H]}{\partial L_{ix}^H} = \frac{\sigma-1}{\sigma} \tau^{-1} p_x[\varphi_i^H](1-\beta_i) \left(\frac{S_d[\varphi_i^H]}{L_d[\varphi_i^H]}\right)^{\beta_i}. \tag{A6}$$

This shows that when firms want to equalize marginal revenues across markets, $p_x[\varphi_i^H] = \tau p_d[\varphi_i^H]$ immediately follows.

A2 Derivation of Equation (11)

The envelope condition of the dynamic programming problem is found by differentiating the value function (equation (9)) with respect to the state variables $L_i(S_i)$. Isolating the shadow value of employment yields:

$$\begin{aligned}\lambda^H_{Li,t} &= \frac{1}{1+r}\left[\frac{\partial R[\varphi^H_i]}{\partial L^H_i} - w^H_{Li} - \frac{\partial w^H_{Li}}{\partial L^H_i}L^H_i + (1-\rho)(1-\delta)\lambda^H_{Li,t+1}\right],\\ \lambda^H_{Si,t} &= \frac{1}{1+r}\left[\frac{\partial R[\varphi^H_i]}{\partial S^H_i} - w^H_{Si} - \frac{\partial w^H_{Si}}{\partial S^H_i}S^H_i + (1-\rho)(1-\delta)\lambda^H_{Si,t+1}\right].\end{aligned}$$

In steady state, $\lambda^H_{Li,t} = \lambda^H_{Li,t+1}$ and $\lambda^H_{Si,t} = \lambda^H_{Si,t+1}$. Hence, the above equations simplify to:

$$\begin{aligned}\lambda^H_{Li} &= \frac{\frac{\partial R[\varphi^H_i]}{\partial L^H_i} - w^H_{Li} - \frac{\partial w^H_{Li}}{\partial L^H_i}L^H_i}{r+s},\\ \lambda^H_{Si} &= \frac{\frac{\partial R[\varphi^H_i]}{\partial S^H_i} - w^H_{Si} - \frac{\partial w^H_{Si}}{\partial S^H_i}S^H_i}{r+s},\end{aligned} \tag{A7}$$

where $s = \delta + \rho - \rho\delta$.

Combining equations (10) and (A7) yields equation (11).

A3 Derivation of Equations (13) and (14)

To solve the surplus-splitting rule given by equation (12), notice that the optimality condition (10) does not vary with the level of the control variables v^H_{Li}, v^H_{Si}. Hence, the optimal firm size remains constant through time, so that $L^H_i = \left(L^H_i\right)'$ and $S^H_i = \left(S^H_i\right)'$. This steady-state condition and the envelope theorem enable us to write the FOC as given in equation (A7).

Reinserting these expressions together with the workers' gains from employment, $E^H_{Li}[\varphi^H_i] - U^H_{Li} = (w^H_{Li} - rU^H_{Li})/(r+s)$ and $E^H_{Si}[\varphi^H_i] - U^H_{Si} = (w^H_{Si} - rU^H_{Si})/(r+s)$, into the "surplus-splitting" equation (12) yields:

$$\begin{aligned}w^H_{Li} &= \mu\frac{\partial R[\varphi^H_i]}{\partial L^H_i} - \mu\frac{\partial w^H_{Li}}{\partial L^H_i}L^H_i + (1-\mu)rU^H_{Li},\\ w^H_{Si} &= \mu\frac{\partial R[\varphi^H_i]}{\partial S^H_i} - \mu\frac{\partial w^H_{Si}}{\partial S^H_i}S^H_i + (1-\mu)rU^H_{Si}.\end{aligned} \tag{A8}$$

These two equations are linear differential equations in L^H_i and S^H_i, respectively. The solution is given by:

$$\begin{aligned}w^H_{Li} &= (1-\mu)rU^H_{Li} + \mu\left(\frac{\sigma}{\sigma+\beta_i\mu-\mu-\beta_i\sigma\mu}\right)\frac{\partial R[\varphi^H_i]}{\partial L^H_i},\\ w^H_{Si} &= (1-\mu)rU^H_{Si} + \mu\left(\frac{\sigma}{\sigma-\beta_i\mu+\beta_i\sigma\mu-\sigma\mu)}\right)\frac{\partial R[\varphi^H_i]}{\partial S^H_i}.\end{aligned} \tag{A9}$$

This can be seen by noting that

$$\frac{\partial R[\varphi_i^H]}{\partial L_i^H} = \frac{\partial R_d[\varphi_i^H]}{\partial L_i^H} = \frac{\partial R_x[\varphi_i^H]}{\partial L_i^H} = \frac{\sigma - 1}{\sigma} p_d[\varphi_i^H](1-\beta_i)\left(\frac{S[\varphi_i^H]}{L[\varphi_i^H]}\right)^{\beta_i}, \quad \text{(A10)}$$

as firms equate marginal revenues across markets and either employ the marginal worker for domestic or foreign production.

The Job Creation curve is derived by reinserting the revenue function into equations (A9) and differentiating the resulting equations with respect to L_i^H and S_i^H, respectively:

$$\begin{aligned} \frac{\partial w_{Li}^H}{\partial L_i^H} &= \frac{\mu}{L_i^H}\left(\frac{\beta_i - 1 - \beta_i\sigma}{\sigma + \beta_i\mu - \mu - \beta_i\sigma\mu}\right)\frac{\partial R[\varphi_i^H]}{\partial L_i^H}, \\ \frac{\partial w_{Si}^H}{\partial S_i^H} &= \frac{\mu}{S_i^H}\left(\frac{-\beta_i + \beta_i\sigma - \sigma}{\sigma - \beta_i\mu + \beta_i\sigma\mu - \sigma\mu}\right)\frac{\partial R[\varphi_i^H]}{\partial S_i}. \end{aligned} \quad \text{(A11)}$$

We can now substitute $(\partial w_{Li}^H/\partial L_i^H)L_i^H$ and $(\partial w_{Si}^H/\partial S_i^H)S_i^H$ in equation (11) to obtain:

$$\begin{aligned} \frac{\partial R[\varphi_i^H]}{\partial L_i^H} &= \frac{cP_i^H}{m[\theta_{Li}^H]}\frac{s+r}{1-\delta} + w_{Li}^H + \frac{\partial w_{Li}^H}{\partial L_i^H}L[\varphi_i^H] \Rightarrow \\ \frac{\partial R[\varphi_i^H]}{\partial L_i^H} &= \frac{cP_i^H}{m[\theta_{Li}^H]}\frac{s+r}{1-\delta} + w_{Li}^H \\ &+ \left(\mu\left(\frac{\beta_i - 1 - \beta_i\sigma}{\sigma + \beta_i\mu - \mu - \beta_i\sigma\mu}\right)\frac{\partial R[\varphi_i^H]}{\partial L_i^H}\right) \Rightarrow \\ w_{Li}^H &= \left(\frac{\sigma}{\sigma + \beta_i\mu - \mu - \beta_i\sigma\mu}\right)\frac{\partial R[\varphi_i^H]}{\partial L_i^H} \\ &- \frac{cP_i^H}{m[\theta_{Li}^H]}\frac{s+r}{1-\delta}. \end{aligned} \quad \text{(A12)}$$

$$\begin{aligned} \frac{\partial R[\varphi_i^H]}{\partial S_i^H} &= \frac{cP_i^H}{m[\theta_{Si}^H]}\frac{s+r}{1-\delta} + w_{Si}^H + \frac{\partial w_{Si}^H}{\partial S_i^H}S_i^H \Rightarrow \\ \frac{\partial R[\varphi_i^H]}{\partial S_i^H} &= \frac{cP_i^H}{m[\theta_{Si}^H]}\frac{s+r}{1-\delta} + w_{Si}^H \\ &+ \left(\mu\left(\frac{-\beta_i + \beta_i\sigma - \sigma}{\sigma - \beta_i\mu + \beta_i\sigma\mu - \sigma\mu}\right)\frac{\partial R[\varphi_i^H]}{\partial S_i^H}\right) \Rightarrow \\ w_{Si}^H &= \left(\frac{\sigma}{\sigma - \beta_i\mu + \beta_i\sigma\mu - \sigma\mu}\right)\frac{\partial R[\varphi_i^H]}{\partial S_i^H} \\ &- \frac{cP_i^H}{m[\theta_{Si}^H]}\frac{s+r}{1-\delta}. \end{aligned} \quad \text{(A13)}$$

Plugging in equation (A10) into equations (A12) and (A13) directly yields (13).

Finally, we express the Wage Curves as a function of θ^H_{Li} and θ^H_{Si}, respectively, by reinserting (A9) into (A12) and (A13):

$$w^H_{Li} = (1-\mu)rU^H_{Li} + \mu\left(w^H_{Li} + \frac{cP^H_i}{m[\theta^H_{Li}]}\frac{s+r}{1-\delta}\right),$$
$$w^H_{Si} = (1-\mu)rU^H_{Si} + \mu\left(w^H_{Si} + \frac{cP^H_i}{m[\theta^H_{Si}]}\frac{s+r}{1-\delta}\right).$$

Isolating the wage on the left-hand side yields equation (14).

To substitute out the value of unemployment, note that the value functions of skilled workers are (the same relationships hold for unskilled workers):

$$\begin{aligned} U^H_{Si} &= \frac{1}{1+r}\big(b + \theta^H_{Si}m[\theta^H_{Si}]E^H_{Si} + (1-\theta^H_{Si}m[\theta^H_{Si}])U^H_{Si}\big), \\ E^H_{Si} &= \frac{1}{1+r}\left(w^H_{Si} + (1-s)E^H_{Si} + sU^H_{Si}\right). \end{aligned}$$

where $\theta^H_{Si}m[\theta^H_{Si}]$ is an unemployed workers probability to find a new job and b are unemployment benefits. The two equations can be combined to:

$$rU^H_{Si} = b + \theta^H_{Si}m[\theta^H_{Si}]\frac{w^H_{Si} - rU^H_{Si}}{r+s}. \tag{A14}$$

Using the wage curve (14) to substitute out $w^H_{Si} - rU^H_{Si}$ this becomes:

$$rU^H_{Si} = b + \frac{cP^H_i\theta^H_{Si}}{1-\delta}\frac{\mu}{1-\mu}. \tag{A15}$$

Substituting this into equation (14) yields (15).

A4 Productivity Cut-Off Relationship

As in BRS, equilibrium revenue in the export market is proportional to that in the domestic market. However, the relative revenue in the export market now depends on variable trade costs, and price indices now vary across the two countries. Hence, relative price indices enter as a determinant of relative revenue in the export market:

$$R_x[\varphi^H_i] = \tau^{1-\sigma}\left(\frac{P^F_i}{P^H_i}\right)^{\sigma-1}\left(\frac{Y^F}{Y^H}\right)R_d[\varphi^H_i]. \tag{A16}$$

The zero-productivity cut-off above which firms produce for the domestic market, φ^{*H}_{id}, and the costly trade exporting productivity cut-off, above which firms produce for both the domestic and the export markets, φ_{ix}^{*H}, are determined by:

$$R_d[\varphi_{id}^{*H}] = \sigma f P_i^H,$$
$$R_x[\varphi_{ix}^{*H}] = \sigma f_x P_i^H. \tag{A17}$$

Combining these two equations leads to an equation that links the revenues of a firm at the zero-profit productivity cut-off to those of a firm at the exporting productivity cut-off. Further, the relationship between revenues of two firms with different productivities in the same industry and country is given by: $R_d[\varphi_{id}''^H] = \left(\frac{\varphi_{id}''^H}{\varphi_{id}'^H}\right)^{\sigma-1} R_d[\varphi_{id}'^H]$. These two relationships together yield and equilibrium relationship between the two productivity cut-offs:

$$\varphi_{ix}^{*H} = \Lambda_i^H \varphi_{id}^{*H}, \quad \text{where}$$
$$\Lambda_i^H \equiv \tau \left(\frac{P_i^H}{P_i^F}\right)\left(\frac{Y^H}{Y^F}\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}}. \tag{A18}$$

A5 Parameter Restriction for $\beta_i/\sigma/\mu$

First we solve for the quantities produced by one firm by using the zero-profit condition of firms:

$$\frac{(1-\delta)}{r+\delta}\pi_d[\varphi_{id}^{*H}] = f P_i^H + \frac{cP_i^H L[\varphi_{id}^{*H}]}{m[\theta_{Li}^H]} + \frac{cP_i^H S[\varphi_{id}^{*H}]}{m[\theta_{Si}^H]}. \tag{A19}$$

Plugging in this expression into the profit function yields:

$$\frac{(1-\delta)}{r+\delta}\left[q_d[\varphi_{id}^{*H}]p_d[\varphi_{id}^{*H}] - w_{Li}^H L[\varphi_{id}^{*H}] - w_{Si}^H S[\varphi_{id}^{*H}] - \frac{cP_i^H L[\varphi_{id}^{*H}]\rho}{m[\theta_{Li}^H]} - \right.$$
$$\left.\frac{cP_i^H S[\varphi_{id}^{*H}]\rho}{m[\theta_{Si}^H]} - fP_i^H\right] = fP_i^H + \frac{cP_i^H L[\varphi_{id}^{*H}]}{m[\theta_{Li}^H]} + \frac{cP_i^H S[\varphi_{id}^{*H}]}{m[\theta_{Si}^H]} \Rightarrow$$
$$\frac{(1-\delta)}{r+\delta}\left(q_d[\varphi_{id}^{*H}]p_d[\varphi_{id}^{*H}] - w_{Li}^H L[\varphi_{id}^{*H}] - w_{Si}^H S[\varphi_{id}^{*H}]\right)$$
$$-\frac{r+s}{r+\delta}\left(\frac{cP_i^H L[\varphi_{id}^{*H}]}{m[\theta_{Li}^H]} + \frac{cP_i^H S[\varphi_{id}^{*H}]}{m[\theta_{Si}^H]}\right) = \frac{1+r}{r+\delta}fP_i^H.$$

Substituting out the wage using the job-creation condition this becomes:

$$\frac{(1-\delta)}{r+\delta}\left(q_d[\varphi_{id}^{*H}]p_d[\varphi_{id}^{*H}] - \beta_i p_d[\varphi_i^H]\varphi_i^H\left(\frac{S[\varphi_i^H]}{L[\varphi_i^H]}\right)^{\beta_i-1}\frac{\sigma-1}{\sigma-\beta_i\mu+\beta_i\sigma\mu-\sigma\mu}S[\varphi_{id}^{*H}]\right)$$
$$-\frac{(1-\delta)}{r+\delta}\left[(1-\beta_i)p_d[\varphi_i^H]\varphi_i^H\left(\frac{S[\varphi_i^H]}{L[\varphi_i^H]}\right)^{\beta_i}\frac{\sigma-1}{\sigma+\beta_i\mu-\mu-\beta_i\sigma\mu}L[\varphi_{id}^{*H}]\right] = \frac{1+r}{r+\delta}fP_i^H.$$

Using the linear homogeneity property of the Cobb-Dougals production function and $q[\varphi_i^H]p[\varphi_i^H] = \left(\frac{\varphi_i^H}{\varphi_{id}^{*H}}\right)^{\sigma-1} q[\varphi_{id}^{*H}]p[\varphi_{id}^{*H}]$ we can write:

$$\frac{(1-\delta)}{r+\delta}\Bigg(p_d[\varphi_i^H]\varphi_i^H S[\varphi_i^H]_i^\beta L[\varphi_i^H]^{1-\beta_i} - \beta_i p_d[\varphi_i^H]\varphi_i^H S[\varphi_i^H]_i^\beta L[\varphi_i^H]^{1-\beta_i} \times$$
$$\frac{\sigma-1}{\sigma-\beta_i\mu+\beta_i\sigma\mu-\sigma\mu}\Bigg) - \frac{(1-\delta)}{r+\delta}\Bigg((1-\beta_i)p_d[\varphi_i^H]\varphi_i^H S[\varphi_i^H]_i^\beta L[\varphi_i^H]^{1-\beta_i}$$
$$\frac{\sigma-1}{\sigma+\beta_i\mu-\mu-\beta_i\sigma\mu}\Bigg) = \left(\frac{\varphi_i^H}{\varphi_{id}^{*H}}\right)^{\sigma-1}\frac{1+r}{r+\delta} f P_i^H \rightarrow$$
$$\frac{(1-\delta)}{r+\delta}\left(p_d[\varphi_i^H]\varphi_i^H S[\varphi_i^H]_i^\beta L[\varphi_i^H]^{1-\beta_i}\right)\Bigg(1-\beta_i\frac{\sigma-1}{\sigma-\beta_i\mu+\beta_i\sigma\mu-\sigma\mu}$$
$$-(1-\beta_i)\frac{\sigma-1}{\sigma+\beta_i\mu-\mu-\beta_i\sigma\mu}\Bigg) = \left(\frac{\varphi_i^H}{\varphi_{id}^{*H}}\right)^{\sigma-1}\frac{1+r}{r+\delta} f P_i^H.$$

Thus, in order to ensure that quantities and prices are non-negative, the following condition has to hold:

$$1-\beta_i\frac{\sigma-1}{\sigma-\beta_i\mu+\beta_i\sigma\mu-\sigma\mu} - (1-\beta_i)\frac{\sigma-1}{\sigma+\beta_i\mu-\mu-\beta_i\sigma\mu} \geq 0. \tag{A20}$$

This condition gives a restriction on the possible values that can be simultaneously chosen for β_i, σ and μ. In our calibration we take care that this restriction is satisfied.

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