Wage Inequality, Skill-Specific Unemployment and Trade Liberalization

Preliminary Draft

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Abstract

The labor market outcomes of trade liberalization are at the heart of the policy debate. In this model, the long-run effects of trade liberalization and trade-induced skill-biased technological change on wage inequality and unemployment are studied by augmenting a heterogeneous firm trade model with job search and unemployment. In the model, there are two types of workers – skilled and unskilled, and two types of technologies – low and high. Conditional on entry, firms choose which technology to use and whether to export. Then they engage in individual wage bargaining with workers. In the case of two symmetric partners, trade liberalization leads more firms to enter the foreign market and to upgrade technology while leading least productive firms to exit. In the long-run, the redistribution of resources among firms increases both skilled and unskilled wages and reduces the rate of unemployment for both types of workers. Nevertheless, trade liberalization has asymmetric wage effects on the two types of workers: it increases wage inequality in favour of skilled workers. Also, unemployment rate in the skilled-labour market falls to a greater extent, implying a change in the skill composition of unemployment in both trade partners.(JEL F12; F15; F16)

Keywords: Trade Liberalization; Wage Inequality; Unemployment; Search
1 Introduction

Public resists to trade liberalization policies since they fear that such policies might have undesired consequences in the domestic labor market. Although economists and policy makers advocate liberalization by indicating its positive impact on welfare through increased variety and aggregate productivity, there exists empirical evidence that justifies the fear of public. As some sectors close up and some firms exit after trade liberalization, workers formerly employed by these firms/sectors, join the unemployment pool. As globalization reduces the survival probability of low productivity firms and allocate market shares towards more productive and technologically advanced which are also more intensive in skilled labor. For this reason, it is natural to distinguish workers as skilled and unskilled to identify who benefits from trade.

This paper aims to improve our understanding of heterogeneous labor market outcomes of trade liberalization. It develops a Melitz-type trade model that (i) links globalization, skill-biased technological change (SBTC), and wage inequality where labor market is subject to frictions; and (ii) offers a mechanism through which trade liberalization affects unemployment of different skill groups differently. The model’s predictions are consistent with a number of recent stylized facts. It generates new predictions about labor market effects of trade liberalization and reiterates the findings of existing trade models.

The literature on trade liberalization has focused mainly on explaining the observed increase in skill premium—relative wage of skilled to unskilled workers. Figure 1 shows that the ratio of unskilled to skilled unemployment follows a similar trend. Note that if the ratio is equal to 1, unemployment of unskilled is equal to skilled. The unskilled unemployment rate is higher than skilled in Germany, Spain and Italy and lower than skilled unemployment in Greece. Portugal starts with relative unemployment less than 1 and the measure is slightly over 1 after 2005. Yet independent of initial relative unemployment rates, the unemployment of unskilled relative to skilled has an upward trend between 1996-2012 for all the selected countries and EU-15. The upward trend in relative unemployment rate is accompanied by an increase in trade openness in all of these economies. For instance, trade openness of Germany has increased by 50 percentage points whereas openness of Italy, Spain and Portugal go up by 15 percentage points each. Therefore, there may be a room for trade as an explanation of the upward trend of relative unemployment of unskilled. Building upon an extensive literature, we develop a model which embodies a number of stylized facts and tests the effect of liberalization on unemployment of different skill groups.

Recent findings on increase in wage inequality in countries at different stages of development are attributed to the rise in globalization. Goldberg and Pavcnik (2007) and Harrison, McLaren, and McMillan (2010) provide detailed assessments of these findings. A number of new mechanisms have been examined through which trade liberalization alters inequality. Among these channels, we focus on

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1 The relative unemployment rate is \( \frac{\text{unemployment rate, unskilled}}{\text{unemployment rate, skilled}} \) and 3-year moving average of this measure has been calculated since we are interested in the trend.

2 Here skilled labor is defined as graduates of secondary school whereas unskilled labor is primary school graduates. Also the ratio of unemployment rate of primary school graduates relative tertiary school graduates has been used as a measure and similar trend has been observed.

3 Other countries and country groups in European Union or Euro Area, which have statistics for 1996-2012, have a similar trend and are not reported to make figure visually more clear.

4 These mechanisms also include trade in tasks, incomplete contracting, innovation and labor market frictions.
intra-industry reallocation effects of liberalization through skill-biased technological change on workers with observable characteristics. Bas (2008) and Bustos (2011a) find that increase in technology adoption due to globalization raises relative demand for skill and relative wage of skilled labor by using firm-level data from Chile and Argentina, respectively. By calibrating a general equilibrium model Ratts and Stokke (2013) propose that trade-induced skill-biased technological change is an important determinant of wage inequality in South Africa.

To the best of our knowledge, the model developed by Yeaple (2005) is the first attempt to introduce technology choice to a heterogeneous firm trade-model. Yeaple (2005) shows that as trade costs decreases, the number of exporting firms as well as the number of firms utilizing more advanced technology increases. Bas (2008), Bustos (2011b) and Bustos (2011a) introduce some form of technology adoption choice into Melitz (2003). Theoretical findings of these studies suggest that as trade liberalization reallocates market shares toward high productive firms, the fixed costs of technology adoption becomes affordable for some low-tech firms. Consequently, the number of firms using high technology increases. Harrigan and Reshef (2011) and Burstein and Vogel (2010) show that similar results prevail when countries are asymmetric. However, these models are not set up with a focus on unemployment, and so they do not present any results for the effects of liberalization on unemployment rate. Nevertheless, as relative demand for skill is increasing throughout globalization episodes, we have a good reason to believe that unemployment rates for different types of workers are affected differently from trade liberalization.

The most common concern regarding globalization is the transitional unemployment effects of trade liberalization in developing economies. People fear they will lose their jobs after a liberalization pol-
icy. However, there is lack of evidence on how globalization affects transitional unemployment due to unavailability of appropriate statistics. On the other hand, the long-run effects of liberalization on unemployment have been examined in a small number of empirical studies. Recent papers by Dutt, Mitra, and Ranjan (2009) and Felbermayr, Prat, and Schmerer (2011b) discuss the long-run effects of trade openness on unemployment. Dutt, Mitra, and Ranjan (2009) conclude that trade liberalization reduces the aggregate unemployment by employing a cross-country analysis from developing world. Moreover, Felbermayr, Prat, and Schmerer (2011b) provide similar results for OECD countries.

Despite the lack of sufficient evidence on the unemployment effects of globalization, there is quite a number of theoretical models linking unemployment and trade. Here, we focus on heterogeneous firm trade models where trade globalization leads reallocation of resources within an industry. Egger and Kreickemeier (2009) incorporate fair wages into Melitz (2003) and find that trade liberalization can lead to an increase in unemployment. Davis and Harrigan (2011) merge Melitz (2003) with Shapiro and Stiglitz (1984) and suggest that a reduction in trade costs results in destruction of “bad jobs” and creation of “good” jobs whereas the effects of globalization on aggregate unemployment is minimal. Felbermayr, Prat, and Schmerer (2011a) introduce Pissarides-type labor market frictions into Melitz (2003) and show that globalization results in an increase in industry productivity, which in turn, lowers the aggregate unemployment rate. Finally, Helpman, Itskohki, and Redding (2010) examine the unemployment effects of trade liberalization by developing a model with heterogeneous firms and workers and labor market frictions. However, these models do not focus on effects of trade on unemployment of workers with different observable characteristic. Main aim of the analysis presented here is to fill this gap in the literature.

The relative unemployment rate for unskilled worker in terms of skilled has not been at the focus of trade models. A recent evidence on unemployment effect of globalization by Felbermayr, Prat, and Schmerer (2011b) show that trade openness reduces aggregate unemployment. By using a panel statistics from 20 OECD countries, their results also suggest that this effect is primarily due to reductions in unemployment of skilled workers. Given the stylized fact on globalization increases the relative demand for skill in countries at different stages of development, this result is not surprising. Therefore, it is natural to ask whether the upward trend in Figure 1 is due to trade liberalization. In this model, by building on extensive theoretical work, we focus on diverse effects of trade liberalization on unemployment of different types of workers. More specifically, we assess whether globalization have opposite effects on different skill groups, or whether these skill groups unequally benefit from trade liberalization.

The model mostly related to ours is Moore and Ranjan (2005). In Moore and Ranjan (2005), skill-specific unemployment coexists with perfectly competitive good market. Labor market is characterized

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5Davis (1998) introduces minimum wages whereas Davidson, Martin, and Matusz (1999) introduce search generated unemployment to Heckscher-Ohlin.
6Helpman and Itskohki (2010), on the other hand, utilize search frictions as a source of comparative advantage and find that globalization leads higher unemployment rate.
7Davidson, Matusz, and Shevchenko (2008) are first to introduce skill-specific unemployment into a trade framework. In the model, firms are homogeneous and technology adoption is a binary choice. High technology requires skilled worker whereas low-tech jobs can be either accomplished by skilled or unskilled labor. Consistent with other trade models, opening up to trade leads to an allocation of resources towards high-tech firms. However the focus of the analysis is within-firm productivity gains from trade, and so, they do not derive results for unemployment of different types of workers.
by search and matching model of Pissarides (2000). There is only one type of technology available to all firms and SBTC is introduced as an exogenous shock to this production technology. They discuss the effects of globalization and SBTC separately and find that both contribute to the rise in inequality. The results of the model suggest that trade liberalization lead skilled unemployment to fall whereas those of unskilled to rise. SBTC, on the other hand, results in reduction of unemployment for both skill groups if the complementarity of skilled and unskilled good is strong enough. The difference from Moore and Ranjan (2005) is, in the work presented here firms within the same industry are heterogeneous in their productivity. Therefore, firms endogenously decide to enter, to export and to upgrade technology. Therefore, we allow for allocation of market shares to change due to liberalization. Moreover, we provide a model in which the effects of resource reallocation on technology adoption and on relative wage and unemployment of skilled can be examined.

Main findings of the paper are as follows. Independent of the size of exporting and technology adoption costs, trade liberalization leads wages of both skilled and unskilled to increase. Consequently, overall wages increase due to a reduction in variable trade cost. Also, unemployment rates for skilled and unskilled falls due to globalization leading to a decrease in aggregate unemployment. Therefore, both type of skill groups gain from trade. However, trade liberalization affects skilled and unskilled workers differently even in a symmetric country case. As in Bustos (2011a), a reduction in tariffs or transportation costs reallocates resources toward more productive firms, some firms upgrade their technology. Since high technology is skill intensive, relative skill demand and skill premium increases. Finally, liberalization is followed by a change in the composition of unemployment pool. The rise in relative skill demand causes unemployment rate of skilled to fall more than unskilled, leading to an increase in the share of unskilled in total unemployment.

The remainder of the paper is organized as follows. Section 2 gives the set-up of the model. Section 3 describes the wage bargaining process and presents the derivation of Wage and Job Creation curves. Section 4 presents the entry, exporting and technology decisions of firms. In Section 5, the labor market equilibrium is derived for both skill groups to close the model. Section 6, conducts a comparative statics analysis to study the effect of trade liberalization on labor market outcomes. In Section 7, a different scenario which results from the alternative magnitudes of technology and exporting costs, is examined. Section 8 concludes. Proofs of the propositions and derivations of particular equations are in the Appendix.

2 Set-up of the Model

There is a single consumption good which is a CES aggregate of intermediate inputs. Intermediate inputs are either domestically produced or imported. There are two symmetric countries. Intermediate input producers are heterogeneous in their productivity and decide whether to enter and/or export as in Melitz (2003) which are both costly activities. Also firms choose to upgrade their technology by covering technology adoption cost as in Bustos (2011b). In addition, labor market faces search and matching frictions of Diamond-Mortensen-Pissarides type. We incorporate the search and matching by
following the approach of Felbermayr, Prat, and Schmerer (2011a).

**Final output producers**

Single final output \( Y \), either consumed or used as an input, is produced from continuum of intermediate inputs. Denoting quantity of each intermediate input by \( q(\omega) \) and we assume following production function

\[
Y = \left[ M^{\frac{\sigma - 1}{\sigma}} \int_{\omega \in \Omega} q(\omega)^{\frac{\sigma - 1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma - 1}}
\]

and \( M \) is the number of intermediate inputs. Price index dual to (1) is

\[
P = \left[ M^{-1} \int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right]^{1-\sigma}
\]

where \( p(\omega) \) is the price of input \( \omega \). \( \sigma \) is the constant elasticity of substitution, \( \sigma > 1 \). Therefore, the demand for intermediate input \( \omega \) is

\[
q(\omega) = \frac{Y}{M} p(\omega)^{-\sigma}
\]

**Intermediate input producers**

There is a continuum of monopolistically competitive intermediate input producers each producing a different variety with constant elasticity of substitution. There are two types of technologies available to intermediate input producers. Low technology output \( q_\ell(\omega) = \ell(\omega) \varphi(\omega) \) requires unskilled worker \( \ell(\omega) \) whereas high technology output \( q_h(\omega) = h(\omega) \gamma \varphi(\omega) \) requires skilled worker \( h(\omega) \). Marginal product of unskilled worker is \( \varphi(\omega) \) whereas marginal product skilled worker is \( \gamma \varphi(\omega)(\gamma > 0) \). We use \( \varphi \) to index intermediate input producers for the rest of the analysis.

Fixed market access cost for low technology firms is \( f_\ell \) whereas for high technology firms it is \( \eta f_\ell(\eta > 0) \). Note that high technology has lower variable cost but higher fixed cost. \( \tau > 1 \) is the standard iceberg transport cost. Fixed export market cost is same for both low and high technology firms, \( f_X \). Operating revenue from the export market for both technologies is \( p_i^x q_i^x / \tau \) whereas from domestic market it is \( p_i^d q_i^d \) for \( i \in (\ell, h) \). Equating marginal revenues for both technologies suggest that \( p_i^x(\varphi) = \tau p_i^d(\varphi) \). So that \( q_i^x(\varphi) = \tau^{1-\sigma} q_i^d(\varphi) \). Total revenues of a low-tech firm are

\[
r_\ell(\varphi) = \left[ \frac{Y}{M} (1 + I(\varphi) \tau^{1-\sigma}) \right]^{\frac{1}{\sigma}} (\ell \varphi)^{\frac{\sigma - 1}{\sigma}}
\]

and high-tech firm’s revenues are

\[
r_h(\varphi) = \left[ \frac{Y}{M} (1 + I(\varphi) \tau^{1-\sigma}) \right]^{\frac{1}{\sigma}} (h \gamma \varphi)^{\frac{\sigma - 1}{\sigma}}
\]
$I(\varphi)$ is an indicator function that takes value ‘1’ if the firm is exporting and ‘0’ if it is producing only for the domestic market.

**Labor market**

Each country is endowed with $\rho_s L$ units of skilled labor and $(1 - \rho_s) L$ units of unskilled labor, where $L$ is the total labor force. The labor market is defined separately for skilled and unskilled workers. Here, we present the ex-post segmentation equilibrium in which each type of worker matches with firms according to their abilities. In other words, skilled labor works only for high-tech firms whereas unskilled worker is employed only by low-tech firms. Therefore for the rest of the analysis, $\ell$ stands for the unskilled worker in labor market side of the model and it represents the low technology for the firm level variables. Similarly, $h$ represents skilled worker and high technology. Both skilled and unskilled labor market are subject to search frictions.

$\theta_i = \frac{v_i}{u_i}$ where $u_i$ is the number of unemployed workers and $v_i$ is the number of vacancies for $i$-type workers for $i = \ell, h$. Matching function $k(u_i, v_i)$, gives the number of matches for a given $u_i$ and $v_i$. Matching function is constant returns to scale and can be expressed as follows

$$k(u_i, v_i) = k\left(\frac{u_i}{v_i}, 1\right) v_i = m(\theta_i) v_i$$

Note that the ratio of number of matches to vacancies gives us the firms’ job filling rate. $\frac{k(u_i, v_i)}{v_i} = m(\theta_i)$ is $i$-type firm’s job filling rate. $m(\theta_i)$ is uniquely defined by $\theta_i$ and satisfies the following properties: $m'(\theta_i) < 0$, $\lim_{\theta_i \to -\infty} m(\theta_i) = 0$ and $\lim_{\theta_i \to 0} m(\theta_i) = \infty$. On the other hand, the ratio of number of matches to unemployed produces the rate at workers meet firms: $\frac{k(u_i, v_i)}{u_i} = m(\theta_i) \theta_i$. Note that $m(\theta_i) \theta_i$ is an increasing function of $\theta_i$. As vacancy-to-unemployed ratio increases, workers meet firms at a higher rate. $c$ is the cost of posting a new vacancy meaning that recruiting $\ell(\varphi)(\varphi)$ units of unskilled (skilled) worker requires a firm spending of $[c/m(\theta_i)]l(\varphi)\varphi$ units of unskilled (skilled) worker requires a firm spending of $l(\varphi)([c/m(\theta_i)]l(\varphi))$ units of unskilled (skilled) worker requires a firm spending of $[c/m(\theta_i)]l(\varphi)([c/m(\theta_i)]l(\varphi))$ units of unskilled (skilled) worker requires a firm spending of $[c/m(\theta_i)]l(\varphi)([c/m(\theta_i)]l(\varphi))$ units of unskilled (skilled) worker requires a firm spending of $[c/m(\theta_i)]l(\varphi)([c/m(\theta_i)]l(\varphi))$ units of unskilled (skilled) worker requires a firm spending of $[c/m(\theta_i)]l(\varphi)([c/m(\theta_i)]l(\varphi))$.

### 3 Optimal Vacancy Posting and Wage Bargaining

In this section we derive Wage (W) and Job Creation (JC) curves for both skill groups. Wages are bargained individually. $\delta$ is the probability that producers leave the market and $\chi$ is the probability that match is broken. Then, the actual separation rate is $s = \delta + \delta \chi$ assuming that two probabilities are independent from each other. Unemployed unskilled labor earn $b\overline{w}_\ell$ and unemployed skilled labor earn $b\overline{w}_h$ where $b \in (0, 1)$ and, $\overline{w}_\ell$ and $\overline{w}_h$ are average wages of unskilled and skilled labor, respectively.

First each type of intermediate input producers choose optimal number of vacancies $v_i$ by taking wage rates as given. Afterwards, workers and firms meet and wages are bargained before production taking place. Note that wage contracts are not enforceable. In other words, it is costless for firms to fire employees and workers to quit their jobs.

\[9\] Therefore, the adjustment cost of firm is linear in labor
### 3.1 Number of Optimal Vacancy

Each type of firm determines the optimal number of vacancy to post. Skilled and unskilled search jobs according to their abilities. We restrict our attention to the case where skilled worker would never prefer unskilled jobs.

Low-tech intermediate input producer maximizes its market value

$$J(\ell|\varphi) = \max_{\nu\ell} \frac{1}{1+r} \left\{ r_\ell(\varphi) - w_\ell(\varphi) \ell(\varphi) - c\nu_\ell - f_\ell - I(\varphi)f_X + (1-\delta)J(\ell'|\varphi) \right\}$$ \hspace{1cm} (7)

subject to its revenues (4)

$$r_\ell(\varphi) = \left[ \frac{Y}{M} (1 + I(\varphi)\tau^{1-\sigma}) \right]^{\frac{1}{\sigma}} (\ell(\varphi))^{\frac{\sigma-1}{\sigma}}$$ \hspace{1cm} (8)

and to the law of motion of labor within the firm

$$\ell' = (1-\chi)\ell + m(\theta_\ell)\nu_\ell$$ \hspace{1cm} (9)

The level of firm employment next period is the sum of unbroken matches \((1-\chi)\ell\) and newly hired workers \(m(\theta_\ell)\nu_\ell\). First order condition of the optimization problem (7) is

$$-\frac{c}{m(\theta_\ell)} = (1-\delta)\frac{\partial J(\ell'|\varphi)}{\partial \ell'}$$ \hspace{1cm} (10)

\(-\frac{c}{m(\theta_\ell)}\) is the expected recruitment cost and equals to shadow value of unskilled worker to firm. Taking the derivative of (7) with respect to \(\ell\), iterating one period and substituting into (10) yields

$$\frac{\partial J(\ell|\varphi)}{\partial \ell} = \frac{1}{1+r} \left\{ \frac{\partial r_\ell(\varphi)}{\partial \ell} - w_\ell(\varphi) - \frac{\partial w_\ell(\varphi)}{\partial \ell} \ell(\varphi) - \frac{c}{m(\theta_\ell)} (1-\chi) \right\}$$ \hspace{1cm} (11)

Here firms are acting like a monopsonist since they are taking into account the effect of hiring one more worker on the wage of employees. Low-tech firms decide on optimal number of vacancy using first order condition (10). Equation (11) incorporates law of motion of employment and therefore pins down the optimal level of output. the price of the intermediate input is achieved by replacing (10) in (11)

$$\frac{\partial r_\ell(\varphi)}{\partial \ell} = \frac{\sigma-1}{\sigma} P^d_\ell(\varphi) = w_\ell(\varphi) + \frac{\partial w_\ell(\varphi)}{\partial \ell} \ell(\varphi) + \frac{c}{m(\theta_\ell)} \frac{r+s}{1-\delta}$$ \hspace{1cm} (12)

Note that marginal cost of worker is only equal to wage in a perfectly competitive labor market. Here, in addition to wages, hiring a unskilled worker has two additional costs. \(\frac{\partial w_\ell(\varphi)}{\partial \ell} \ell(\varphi)\) represents the monopsony power of low-tech firms whereas \(-\frac{c}{m(\theta_\ell)} \frac{r+s}{1-\delta}\) is the expected cost of recruiting the worker.

Similarly, high-tech intermediate input producer solves

$$J(h|\varphi) = \max_{\nu h} \frac{1}{1+r} \left\{ r_h(\varphi) - w_h(\varphi)h(\varphi) - c\nu_h - \eta f_\ell - I(\varphi)f_X + (1-\delta)J(h'|\varphi) \right\}$$ \hspace{1cm} (13)
subject to high-tech firm’s revenues (5)

\[ r_h(\varphi) = \left[ \frac{Y}{M} (1 + I(\varphi) \tau^{1-\sigma}) \right]^{\frac{1}{\sigma}} (h\gamma\varphi)^{\frac{\sigma-1}{\sigma}} \]  

(14)

and to the law of motion of labor in skilled firm

\[ h' = (1 - \chi)h + m(\theta_h)\nu_h \]  

(15)

First order condition of the optimization problem reads

\[ \frac{c}{m(\theta_h)} = (1 - \delta) \frac{\partial J(h'|\varphi)}{\partial h'} \]  

(16)

Analogous to (11) and (12), optimal vacancy posting condition and pricing rule firms using high technology can be written as

\[ \frac{\partial J(h|h)}{\partial h} = \frac{\sigma - 1}{\sigma} p_h^d(\varphi) \varphi = \frac{1}{1 + r} \left\{ \frac{\partial r_h(\varphi)}{\partial h} - w_h(\varphi) \right\} \]  

(17)

\[ \frac{\partial r_h(\varphi)}{\partial h} = w_h(\varphi) + \frac{\partial w_h(\varphi)}{\partial h}\varphi + \frac{c}{m(\theta_h)} (1 - \chi) \]  

(18)

3.2 Wage Bargaining

In this section, Wage and Job Creation Curves for both skilled and unskilled market will be derived. The details of the derivations can be found in Appendix (A1).

Once the firm and the worker successfully matched, total surplus of the match is split between the firm and the worker. \( E(i, \varphi) \) is the value of being employed to the worker of type \( i \) whereas \( U_i \) is the value being unemployed. On the firm side, \( \frac{\partial J(i|\varphi)}{\partial i} \) is the value of one more vacancy to \( i \) type firm. Both type of firms earns zero rent from a vacant job. Then, under Nash bargaining the wage rate satisfies

\[ w_i = \arg \max (E(i, \varphi) - U_i) \beta \left( \frac{\partial J(i|\varphi)}{\partial i} \right)^{1-\beta} \]  

(19)

where \( \beta \) is the bargaining power of the worker and belongs to (0,1). First order condition of (19) satisfies

\[ (1 - \beta)[E(i, \varphi) - U_i] = \beta \frac{\partial J(i|\varphi)}{\partial i} \]  

(20)

Inserting (11) and (17) into (20) yields two ordinary differential equations for both skill groups. The solution to these equations is combined with the outside option of both type of workers \( rU(\theta_i) \) to obtain wage curves in both labor markets.

\[ w_e = \frac{\beta}{1 - \beta} \frac{1}{1 + \delta} \frac{c}{m(\theta_e)} \left[ \theta_e + \frac{r + s}{m(\theta_e)} \right] \]  

(21)
Note that wage curve is the labor supply equivalent of Walrasian models. Wage Curve posits a positive relation between wage rate and the labor market tightness. A higher market tightness $\theta_i$ shows that jobs meet workers at higher rate than workers meet vacant jobs. Therefore bargaining strength of the worker becomes higher than the firm which in turn leads to a higher wage rate. Combining the solutions of the ordinary differential equations with the demand for intermediate inputs (3) yields the Job Creation curves for both type of markets.

$$w_h = \frac{\beta}{1-\beta} \frac{1}{1-\delta} \left[ \frac{\theta_h + r + s}{m(\theta_h)} \right]$$  \hspace{1cm} (22)

Job creation curve is the labor demand equivalent of Walrasian models suggesting a negative relation between wage rate and the labor market tightness. At a higher wage rate $w_i$, it is more costly to hire an employee. This leads firms to post less vacancy, and consequently, to market tightness $\theta_i$ to fall.

Note that since $P = 1$, $w_i$ is the real wage of type i worker. Also the Job Creation curves suggest that $w_i$ depends on the average productivity level of i type firms. Therefore, within the same technology workers are paid the same wages regardless from the productivity levels of the firms which they are employed in.

Case-I

3.3 Firm Entry, Exporting and Technology Choice

Entry and exporting decisions of the firms are analogous to Melitz model. The technology adoption idea is incorporated in a similar fashion to Bustos (2011b). The aim of the analysis presented in this section is to show how labor market tightness in both labor markets and entry, exporting and technology decisions interact.

Firms pay an entry cost $f_e$. Then, they draw their productivity from a sampling distribution $G(\phi)$ which has a p.d.f. $g(\phi)$ and support over $(0, \infty)$. After the drawing, the productivity of each firm remains constant. Let’s define $\phi_d^*$ as cutoff productivity for entry (or exit). Similarly, define $\phi_x^*$ and $\phi_h^*$ as cutoff productivities for exporting and technology adoption, respectively. Then the ex-ante probability of successful entry is $\rho_d = 1 - G(\phi_d^*)$. The probability of exporting is $\rho_x = \frac{1-G(\phi_x^*)}{1-G(\phi_d^*)}$ and the probability of adopting the high technology is $\rho_h = \frac{1-G(\phi_h^*)}{1-G(\phi_d^*)}$.

Without any exogenous shock, at the steady state, firms do not change their sizes: $\ell' = \ell \implies v_\ell = \frac{\ell(\phi)\chi}{m(\theta_\ell)}$ and $h' = h \implies v_h = \frac{h(\phi)\chi}{m(\theta_h)}$. At the end of the first period firms reach their optimal size since the
adjustment cost function is linear in labor.

\[
J(i|\varphi) = \frac{\Pi_{d}^{i}(\varphi)}{1 + r} + \frac{1 - \delta}{1 + r}J(i'|\varphi) = \frac{\Pi_{d}^{i}(\varphi)}{r + \delta}
\]  
(25)

for \(i \in (\ell, h) j \in (d, x)\). It is profitable for a low-tech firm to start producing when

\[
\frac{\Pi_{d}^{d}(\varphi)}{r + \delta} = \frac{1 - \delta}{r + \delta} \pi_{d}^{d}(\varphi) - \frac{c}{m(\theta_{d})} l_{d}^{d}(\varphi) - f_{x} \geq 0
\]  
(26)

where \(\pi_{d}^{d}(\varphi)\) is the flow profit of low-tech firm from domestic sales:

\[
\pi_{d}^{d}(\varphi) = \left[ \frac{p_{d}^{d}(\varphi) \varphi l_{d}^{d}(\varphi)}{\tau} - w_{d} l_{d}^{d}(\varphi) - \frac{c}{m(\theta_{d})} l_{d}^{d}(\varphi) - f_{x} \right]
\]  
(27)

It is important to note that the last two terms in (26) ensure that low technology firms enter the market and post vacancies one period before production takes place. Accordingly, the firms pay the fixed market access cost and cost of posting vacancies upfront. However, in the period without any production, they can exit the market due to an exogenous shock with probability \(\delta\).

A low-tech firm’s profit from foreign sales is

\[
\frac{\Pi_{d}^{x}(\varphi)}{r + \delta} = \frac{1 - \delta}{r + \delta} \pi_{d}^{x}(\varphi) - \frac{c}{m(\theta_{d})} l_{d}^{x}(\varphi) - f_{x}
\]  
(28)

where \(\pi_{d}^{x}(\varphi)\) is the flow profit of low-tech firms from foreign sales and it is equal to

\[
\pi_{d}^{x}(\varphi) = \left[ \frac{p_{d}^{x}(\varphi) \varphi l_{d}^{x}(\varphi)}{\tau} - w_{d} l_{d}^{x}(\varphi) - \frac{c}{m(\theta_{d})} l_{d}^{x}(\varphi) - f_{x} \right]
\]  
(29)

Analogous to (26), domestic profits of a high-tech firm earns

\[
\frac{\Pi_{h}^{d}(\varphi)}{r + \delta} = \frac{1 - \delta}{r + \delta} \pi_{h}^{d}(\varphi) - \frac{c}{m(\theta_{h})} h_{d}^{d}(\varphi) - \eta f_{\ell}
\]  
(30)

from domestic sales. \(\pi_{h}^{d}(\varphi)\) is the flow profit of a high-tech firm and it is equal to

\[
\pi_{h}^{d}(\varphi) = \left[ \frac{p_{h}^{d}(\varphi) \varphi h_{d}^{d}(\varphi)}{\tau} - w_{h} h_{d}^{d}(\varphi) - \frac{c}{m(\theta_{h})} h_{d}^{d}(\varphi) - \eta f_{\ell} \right]
\]  
(31)

A high-tech firm’s exporting profit is

\[
\frac{\Pi_{h}^{x}(\varphi)}{r + \delta} = \frac{1 - \delta}{r + \delta} \pi_{h}^{x}(\varphi) - \frac{c}{m(\theta_{h})} h_{d}^{x}(\varphi) - f_{x}
\]  
(32)

where \(\pi_{h}^{x}(\varphi)\) is the flow foreign profit of a high-tech firm:

\[
\pi_{h}^{x}(\varphi) = \left[ \frac{p_{h}^{x}(\varphi) \varphi h_{d}^{x}(\varphi)}{\tau} - w_{h} h_{d}^{x}(\varphi) - \frac{c}{m(\theta_{h})} h_{d}^{x}(\varphi) - f_{x} \right]
\]  
(33)
Following Bustos (2011b), first we will consider the case in which technology costs are high enough so that:

$$\frac{\eta - 1}{\lambda^{\sigma - 1}} > \frac{f_x}{f_x}(1 + \tau^{\sigma - 1})$$

(34)

where \(\lambda\) is the marginal cost advantage of high technology and \(\lambda > 1\). We will pin down the marginal cost advantage in this section.

Under this case, it is less costly for firms to start exporting than to upgrade technology. Consequently, the ordering of cutoff productivities is \(\varphi^*_d < \varphi^*_x < \varphi^*_h\). The least productive firms will produce only for domestic market and use low technology. Firms with productivity more than \(\varphi^*_d\) and less than \(\varphi^*_x\) operate under low technology and serve both for domestic and foreign markets. Finally, the firms above technology cutoff use the higher technology and serve for both markets.

**Entry** - Since the least productive firms are using low technology and serving only domestic market, the zero cutoff profit (ZCP) condition for entry is \(\frac{\Pi^d(\varphi^*_d)}{r + \delta} = 0\).

$$\left[ p^d_\ell(\varphi^*_d) - \frac{c}{m(\theta_\ell)} \frac{r + s}{1 - \delta} \right] \varphi^*_d = \frac{r + 1}{1 - \delta} f_\ell$$

(35)

**Exporting** - Firms with productivity levels above \(\varphi^*_x\) earn positive profits from foreign sales. Then ZCP condition for exporting is \(\frac{\Pi^x(\varphi^*_x)}{r + \delta} = 0\) which yields

$$\left[ p^x_\ell(\varphi^*_x) - \frac{c}{m(\theta_\ell)} \frac{r + s}{1 - \delta} \right] \varphi^*_x = \frac{r + 1}{1 - \delta} f_x$$

(36)

Combining two ZCP conditions (35) and (36), one can express \(\varphi^*_x\) in terms of \(\varphi^*_d\)

$$\left( \frac{\varphi^*_x}{\varphi^*_d} \right) = \left( \frac{f_x}{f_\ell} \right) \frac{1}{\tau}$$

(37)

Note that, as long as \(\left( \frac{f_x}{f_\ell} \right) \frac{1}{\tau} > 1\), exporting cutoff \(\varphi^*_x\) is higher than exit cutoff \(\varphi^*_d\). This assumption ensures some firms to produce only for domestic market. Moreover, a reduction in variable trade cost of fixed exporting costs result in an increase in the number of exporting firms upon survival.

**For Technology Choice** - Marginal firm which adopts high technology is indifferent between two technologies. In other words, additional profit from upgrading technology for the marginal firm is equal to '0'. Therefore, ZCP condition is \(\frac{\Pi^d(\varphi^*_h)}{r + \delta} + \frac{\Pi^x(\varphi^*_h)}{r + \delta} = \frac{\Pi^d(\varphi^*_h)}{r + \delta} + \frac{\Pi^x(\varphi^*_h)}{r + \delta}\). The cutoff productivity for technology adoption \(\varphi^*_h\) is pinned down by ZCP for technology adoption.

$$\frac{1 - \delta}{r + \delta} \left[ p^d_\ell(\varphi^*_h) - \frac{c}{m(\theta_\ell)} \frac{r + s}{1 - \delta} \right] \varphi^*_h = \frac{r + 1}{r + \delta} f_\ell$$

(38)
Combining ZCP conditions (35) and (38) gives the relation between technology adoption and entry cutoffs

\[
\left(\frac{\varphi_h^* \phi_h^*}{\varphi_d^*}\right) = \left[\frac{\eta - 1}{(\tau^{1-\sigma} + 1)(\lambda^{\sigma-1} - 1)}\right]^{\frac{1}{\sigma-1}}
\]

(39)

where

\[
\lambda = \frac{\gamma}{\frac{w_h + m(\theta_h) \tau^{1-\sigma}}{w + \frac{m(\theta_h)}{\tau^{1-\sigma}}}}
\]

(40)

\(\lambda\) can be interpreted as the marginal cost advantage of high technology, as in Bustos (2011b) and it is greater than ‘1’ so that technology adoption is profitable. However, different than Bustos (2011b), labor market frictions lead skill premium perceived by workers to be different than skill premium paid by firms. While skill premium perceived by workers \(\frac{w_h}{w}\), skill premium paid by firms is \(\frac{w_h + m(\theta_h) \tau^{1-\sigma}}{w + \frac{m(\theta_h)}{\tau^{1-\sigma}}}\). This comes from the fact that firms are paying hiring costs in addition to wages paid to workers. As skill premium paid by firms increases, the marginal cost advantage of high technology falls. Consequently, lower portion of survived firms upgrade technology. Using Wage curves (21) and (22) and Job Creation curves (23) and (24), it can be shown that \(\lambda\) is solely a function of tightness of both labor markets:

\[
\lambda = \frac{\gamma}{\beta \theta_h + \left(1 - \delta + \frac{b}{\theta_h}\right)(r - \delta)}
\]

\[
\beta \theta_x + \left(1 - \delta + \frac{b}{\theta_x}\right)(r - \delta)
\]

(41)

Since \(m(\theta_i)\) is a decreasing function of \(\theta_i\), \(\lambda\) decreases as relative skilled tightness \(\left(\frac{\theta_h}{\theta_x}\right)\) goes up.

On the other hand, as variable trade cost \(\tau\) decreases, the marginal cost of serving for foreign market falls. More low-tech firms start to afford the fixed cost of high technology and \(\varphi_h^* \phi_h^*\) falls. In other words, the number of firms using high technology conditional on survival increases.

**Free Entry** - (36) and (39) capture the relationships of entry cutoff with exporting and technology cutoffs, respectively. Still, we need to pin down the entry cutoff. Free Entry (FE) condition will allow us to define entry decisions of firms. More specifically, FE accounts for the fact that, firms bare the sunk cost for entry only if they expect positive profits.

\[
f_e = [1 - G(\varphi_d^*)] \frac{\Pi}{r + \delta}
\]

(42)

where

\[
\frac{\Pi}{r + \delta} = \frac{\Pi_d^i}{r + \delta} + \rho_x \frac{\Pi_x^i}{r + \delta} + \rho_h \frac{\Pi_h^i}{r + \delta}
\]

(43)

\(\rho_e, \rho_x\) and \(\rho_h\) are probability of entry, exporting and technology adoption, respectively. \(\Pi\) is the average expected profit of the industry where as \(\Pi_i\) is the average expected profit of \(i\)-type firms from \(j\) market for \(i \in (\ell, h)\), \(j \in (d, x)\). Interpretation of FE condition is as follows. A firm which enters the industry will start to produce with probability of \(1 - G(\varphi_d^*)\) and earn an average expected profit of \(\overline{\Pi}\).
Note that for the rest of the analysis, a Pareto distribution is assumed for the productivity of firms. Pareto distribution has the cumulative distribution function \( G(\varphi) = 1 - \varphi^{-k} \) and the probability distribution function \( g(\varphi) = k\varphi^{-(k+1)} \) where \( k > \sigma - 1 \). Accordingly, the probability for entry, exporting and adopting higher technology are as follows

\[
\rho_e = 1 - G(\varphi^*_d) = (\varphi^*_d)^{-k} \tag{44}
\]

\[
\rho_x = \frac{1 - G(\varphi^*_x)}{1 - G(\varphi^*_d)} = \left( \frac{\varphi^*_x}{\varphi^*_d} \right)^{-k} \left( \frac{f_x}{f_\ell} \right)^{\frac{k}{\sigma-1}} \tau^{-k} \tag{45}
\]

\[
\rho_h = \frac{1 - G(\varphi^*_h)}{1 - G(\varphi^*_d)} = \left( \frac{\varphi^*_h}{\varphi^*_d} \right)^{-k} \left[ \frac{\eta - 1}{(\tau^{1-\sigma} + 1)(\lambda^{\sigma-1} - 1)} \right]^{\frac{k}{\sigma-1}} \tag{46}
\]

Solving for expected profits yields\(^{10}\)

\[
(\varphi^*_d) = \Psi^{\frac{1}{k}} \left[ f_\ell + \rho_x f_x + (\eta - 1)\rho_h f_\ell \right] \tag{47}
\]

where \( \Psi = \left[ \frac{r+1}{r+\delta} \frac{\sigma-1}{k-\sigma+1} \frac{1}{f_\ell} \right] \).

Note that \( \rho^*_x \) depends only on exogenous fixed costs of production and exporting \((f_\ell f_x)\) and on variable cost \(\tau\). \( \rho^*_h \), on the other hand, endogenously determined by \( \frac{\theta_h}{\theta_\ell} \). Therefore, entry cutoff is pinned down by relative labor market tightness measures for both skill groups.

### 3.4 Equilibrium

#### 3.4.1 Unemployment

Let \( k(\theta_i) \) is the number of matches given the search frictions \( \theta_i = \frac{u_i}{u_i} \) in the labor market for i type workers. The matching function is assumed to have the following Cobb-Douglas form for analytical tractability: \( k(\theta_i) = m_0 u_i^\alpha v_i^{1-\alpha} \) where \( 0 < \alpha < 1 \). Then, the rate at which firms fill their jobs can be expressed as \( m(\theta_i) = m_0 \theta_i^{-\alpha} \) whereas the rate workers find jobs becomes \( m(\theta_i) = m_0 \theta_i^{1-\alpha} \). At the steady state, flow out of unemployment should be equal to flow into unemployment for both type of workers:

\[
m_0 \theta_i^{1-\alpha} u_i = s(1 - u_i) \tag{48}
\]

Left-hand side of the equality is the measure of unemployed workers who find jobs whereas right-hand side represents the separation of workers with jobs. Therefore, the fraction of i type workers who are unemployed can be written as

\[
u_i = \frac{s}{s + m_0 \theta_i^{1-\alpha}} \tag{49}
\]

This is the standard Beveridge Curve that links unemployment to the level of labor market tightness. Unemployment is a decreasing function of labor market tightness suggesting that as vacancy to

\(^{10}\)Details of the derivation are provided in Appendix (A.2).
unemployment ratio ($\theta_i$) increases, it is more likely for workers to find jobs.

### 3.4.2 Labor Market Equilibrium

To close the model, labor market equilibrium will be defined. In equilibrium, for both skilled and unskilled workers, the number of workers who find jobs should be equal to the number of workers who are hired by firms. Unskilled workers who match with low-tech jobs (which is denoted as Labor Supply (LS)) can be derived as

$$LS_i(\theta_i) = (1 - u_i)(1 - \rho_s)L = \frac{m_0\theta_i^{1-\alpha}}{s + m_0\theta_i^{1-\alpha}}(1 - \rho_s)L$$

(50)

Note that $LS_i$ is only a function of the tightness in unskilled labor market. Higher vacancy-to-unemployed ratio corresponds to a higher wage, and so, labor supply increases. Analogous to (50), $LS_h$ equation is expressed as follows

$$LS_h(\theta_h) = (1 - u_h)\rho_sL = \frac{m_0\theta_h^{1-\alpha}}{s + m_0\theta_h^{1-\alpha}}\rho_sL$$

(51)

On the demand side, demand for skilled workers by low-tech firms yields the following equation (which is denoted as Labor Demand (LD)):

$$LD_i(\theta_i, \theta_h) = \int_{\phi_d^*}^{\phi_d^*} \ell_d(\phi) \frac{g(\phi)}{1 - G(\phi_d^*)} d\phi + \rho_s(1 + \tau^{1-\sigma}) \int_{\phi_d^*}^{\phi_d^*} \ell_d(\phi) \frac{g(\phi)}{1 - G(\phi_d^*)} d\phi$$

$$= A \frac{1 + \frac{\rho_s f_X - \rho_h(\eta-1)}{\beta \theta_i}}{\beta \theta_i + \frac{(1-b+b\beta)(r+s)}{m_0\theta_i^{1-\alpha}}}$$

(52)

Note that probability of adopting high technology ($\rho_h$) depends on marginal cost advantage of high technology ($\lambda$). In turn, the marginal cost of advantage of high technology is a function of tightness measures of both skill groups ($\theta_i, \theta_h$). Since other parameters in $LD_i$ are exogenous, this function can be expressed solely in terms of two endogenous labor market tightness measures.

The labor demand condition of skilled workers can be expressed as follows

$$LD_h(\theta_i, \theta_h) = \rho_h(1 + \tau^{1-\sigma}) \int_{\phi_h^*}^{\phi_h^*} \ell_d(\phi) \frac{g(\phi)}{1 - G(\phi_h^*)} d\phi$$

$$= A \frac{\rho_h(\eta-1)\lambda^{\sigma-1}}{\lambda^{\sigma-1} - 1} \frac{1}{\beta \theta_h + \frac{(1-b+b\beta)(r+s)}{m_0\theta_h^{1-\alpha}}}$$

(53)

Again, the labor demand for skilled workers endogenously determined only by labor market tightness for both skill groups.

---

11 This result is a direct implication of the implicit assumption of immobility between skill groups.
At equilibrium, \( LD_i = LS_i \) for each type of workers. Unskilled labor market clears where

\[
A \frac{1 + \frac{\rho_x f x}{f_L} - \frac{\rho_h (q-1)}{\lambda^q - 1}}{\beta \theta + \frac{(1-b+\beta) (r+s)}{m_0 \theta^{1-\alpha}}} = - \frac{m_0 \theta^{1-\alpha}}{s + m_0 \theta^{1-\alpha} (1 - \rho_s)L}
\]  

(54)

and skilled labor market equilibrium is

\[
A \frac{\rho_h (q-1) \lambda^{q-1}}{\beta \theta_h + \frac{(1-b+\beta) (r+s)}{m_0 \theta_h^{1-\alpha}}} = \frac{m_0 \theta_h^{1-\alpha}}{s + m_0 \theta_h^{1-\alpha} \rho_s L}
\]  

(55)

where

\[
A = \frac{(r+1)(\sigma-1)(1-b)kf_L}{(k-\sigma+1)c}
\]  

(56)

Hereby, we are left with two equations with two endogenous endogenous variables. In the next section, we provide comparative statics results by using these two equations.

### 3.5 Results of the Comparative Statics

In this section, the effects of trade liberalization on wages and unemployment of both skilled and unskilled workers are examined. Here, trade liberalization is defined as the reduction in variable trade cost \((\tau)\). First, the net effects of liberalization on skilled and unskilled labor market will be presented separately. Later, the direct and indirect effects operating behind these results will be discussed. Finally, we investigate how wage inequality and relative unemployment rate responds to globalization.\(^{12}\)

The model suggests that trade liberalization leads vacancy to unemployment ratio in unskilled labor market to increase:

\[
\frac{d\theta}{d\tau} < 0
\]

This is the net result of trade liberalization on unskilled labor market. As variable trade cost falls, the ratio of unskilled vacancies to unskilled unemployed goes up. It becomes easier for unskilled workers to find jobs and more difficult for low-tech firms to fill their vacancies. Consequently, unskilled wage rises and unemployment of unskilled declines. There are direct and indirect effects that are driving this increase in search frictions due to a fall in \(\tau\).

First direct effect comes from the fact that liberalization leads the probability of entry \((\rho_x = (\varphi_d^*)^{-k})\) to decrease and least productive firms to exit. In other words, entry cutoff \((\varphi_d^*)\) goes up. Since least productive firms are operating with low-technology, exit of these firms breaks up the existing matches between firms and unskilled labor. Accordingly, the demand for unskilled falls leading to a reduction in unskilled vacancies. As some unskilled workers join to unemployment pool, vacancy to unemployed ratio \((\theta)\) falls.

Second effect is, a reduction in variable trade cost \((\tau)\) is accompanied by an increase in the fraction of surviving firms which export (i.e. \(\frac{\varphi_x^*}{\varphi_d^*}\) falls). In other words, the probability of exporting, \(\rho_x = (\varphi_d^*)^{-k}\)

\(^{12}\)For detailed derivations and proofs of this section see Appendix (A.3)
rises. Therefore, higher share of low-tech firms start to serve for both domestic and foreign markets and expand their production. In addition, low-tech firms, which are already in export market, face a fall in their marginal cost of serving for foreign market. These firms increase their scale as well. Both of these events contribute to an increase in demand for unskilled labor, driving up the unskilled vacancy number and unskilled labor market tightness.

Finally, liberalization endogenously induces a skilled-biased technological change. As $\tau$ falls, the fraction of surviving firms that adopt higher technology increases (or $\frac{\phi^*_h}{\phi^*_d}$ falls). Accordingly, the probability of technology adoption $\rho_h = \left(\frac{\phi^*_h}{\phi^*_d}\right)^{-k}$ rises. Therefore, higher share of firms start to afford fixed costs of high technology. As these more firms use high technology, demand for unskilled, and so, the number of unskilled vacancies fall. Such a decrease in demand for unskilled causes vacancy to unemployed ratio $(\theta)$ to fall.

Note that the exit of least productive firms and endogenous skill-biased technological change pushes unskilled labor market tightness down whereas expansion of low-tech exporters increases the tightness. Consequently, the direct effect of liberalization on unskilled labor market is ambiguous. In contrast, for skilled labor market there are two direct effects of liberalization both working in same direction.

The results of the model points to an increase in tightness in skilled labor market due to reduction in $\tau$: 

$$\frac{d\theta_h}{d\tau} < 0$$

Similarly, at equilibrium, trade liberalization results in an increase in the ratio of skilled vacancies to skilled unemployed. Skilled workers find jobs more easily and it is less likely for high-tech firms to fill their vacancies. Again, skilled wage rises and unemployment of skilled declines.

As the share of firms operating with hight technology increases skill demand rises. Moreover, the high-tech firms expand their share in foreign market as exporting becomes a less costly activity which further augment the skilled labor demand. This, in turn, give rises to skilled vacancy increase. Therefore, liberalization stir up the demand for skill and skilled labor market tightness ($\theta_h$) goes up accordingly.

Yet there is an indirect channel through which liberalization affect the skilled and unskilled labor market tightness. This channel works through marginal cost advantage of high technology ($\lambda$). As stated above, $\lambda$ is a function of relative labor market tightness. (See Equation [41]) If skilled tightness relative to unskilled goes up, $\lambda$ falls. In this case, the reduction in $\lambda$ results in a decline in the share of firms that enter ($\phi^*_d$ increases). Moreover, as marginal cost advantage of high-technology falls, less firms adopt higher technology leading to a decrease in probability of technology adoption ($\rho_h$). As a result of a fall in $\lambda$ relative skill demand falls. The skilled tightness relative to unskilled goes down. In order to identify the liberalization’s impact on labor market through $\lambda$, we need to find the effect of $\tau$ on $\theta_h$.

Comparative statics results suggest that $|\frac{d\theta_u}{d\tau}| < |\frac{d\theta_h}{d\tau}|$. In other words, the impact of trade on skilled labor market is higher than its impact on unskilled labor market in absolute value. Therefore, $\lambda$ falls due to a fall in $\tau$. Consequently, the indirect effect of liberalization reduces the relative demand for skill. In the following table, a summary of these findings are presented.
Table 1: The Effects of Trade Liberalization

Table 1 indicates that entry and technology probabilities move in different directions due to direct and indirect effects. However, for these two probabilities direct effect dominates. Moreover, the probability of exporting is only affected from liberalization through its direct effect. The implication of this result on skilled labor market is clear. By increasing the share of high-tech firms and expanding the scale of high-tech exporters, liberalization increases the demand for skill. Skilled vacancy-to-unemployed ratio increases leading to a rise in wages and a decline in unemployment rate of skilled.

For unskilled workers, we have shown that overall effect of a reduction in variable trade cost is higher labor market tightness and wages and lower unemployment rate. “Net Effect” column of Table 1 shows that increase in unskilled labor market tightness results from the increase in the share of exporting firms. As the more low-tech firms enter to foreign markets and existing low-tech exporters expand, unskilled demand rises. However, the exit of least productive firms and an increase in technology adoption by some low-tech firms reduce this positive effect on unskilled labor market tightness but do not eliminate it completely.

Overall, both skilled and unskilled worker benefit from trade liberalization. However, the distribution of gains is not symmetric. As stated above, the impact of trade on skilled labor market is greater than unskilled: \( |\frac{d\theta_h}{d\tau}| < |\frac{d\theta_\ell}{d\tau}| \). This piece of information allows us to examine the effect of trade on skill premium and relative unemployment rate.

Equilibrium skill premium can be written as a function of \( \theta_\ell \) and \( \theta_h \):

\[
\frac{w_h}{w_\ell} = \frac{[\theta_h + (r+s)m(\theta_h)]}{[\theta_\ell + (r+s)m(\theta_\ell)]}
\]

Note that skill premium is an increasing function of \( \frac{\theta_h}{\theta_\ell} \). Therefore, a reduction in \( \tau \) pushes up both type of wages, increasing wage of skilled more than unskilled.

Moreover, from the previous findings in the literature we know that globalization leads skill demand to increase. The mirror image of this finding would be, keeping skill supply constant, trade liberalization results in an increase in the relative unemployment rate of unskilled to skilled. Again, expressing the relative unemployment rates in terms of labor market tightness measures yields

\[
\frac{u_\ell}{u_h} = \frac{s + m(\theta_h)}{s + m(\theta_\ell)}
\]

Since the ratio is an increasing function of relative labor market frictions, our finding on relative effect
of trade liberalization, \( |\frac{d\theta}{d\tau}| < |\frac{d\theta}{d\tau}| \), suggests that relative unemployment rate of unskilled workers increases. In other words, trade liberalization changes the composition of unemployment and unskilled workers start to constitute a larger portion of unemployment pool.

Therefore testable predictions of the model can be summarized as follows. Trade liberalization

1. reallocates market shares toward more productive firms.
2. leads more firms to start exporting and adopt high technology.
3. increases the wages of skilled and unskilled workers.
4. increases the relative demand for skilled workers.
5. leads skilled wage to increase more than unskilled.
6. decreases the unemployment rate of both skill groups.
7. leads unemployment of skilled worker to fall to a greater extent so that the unskilled unemployment relative to skilled unemployment goes up.

### 4 Case-II

If the exporting costs are high enough so that

\[
\frac{\eta - 1}{\lambda^{\sigma-1}} < \frac{f_x}{f_\ell} (1 + \tau^{\sigma-1})
\]  

(57)

then, the following ordering of cutoff productivities arises \( \varphi^*_d < \varphi^*_h < \varphi^*_x \). In this case, firms with low productivity levels produce only for domestic market and use low technology. Firms that operates with a productivity level over \( \varphi^*_h \) and below \( \varphi^*_x \) produce high-tech products and serve for the domestic market. Finally, firms with a productivity level over \( \varphi^*_x \), use high technology and produce for both domestic and foreign markets. Accordingly, all exporters are operating with high technology. Under this alternative scenario, the labor market outcomes of trade liberalization are exactly the same with the main scenario. However, the mechanisms driving these results are different. Only difference of

<table>
<thead>
<tr>
<th>Direct Effect</th>
<th>Indirect Effect</th>
<th>Net Effect</th>
</tr>
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<tbody>
<tr>
<td>( \Delta \text{ in Prob.} )</td>
<td>( \Delta \text{ in Tightness} )</td>
<td>( \Delta \text{ in Prob.} )</td>
</tr>
<tr>
<td>( \rho_c \downarrow )</td>
<td>( \theta_\ell \downarrow )</td>
<td>( \rho_c \uparrow )</td>
</tr>
<tr>
<td>( \rho_h \downarrow )</td>
<td>-</td>
<td>( \rho_h \downarrow )</td>
</tr>
<tr>
<td>( \rho_x \uparrow )</td>
<td>( \theta_\ell \uparrow, \theta_h \uparrow )</td>
<td>( \rho_x \downarrow )</td>
</tr>
</tbody>
</table>

Table 2: The Effects of Trade Liberalization - Alternative Case

this case from the previous one is, now tariff or transportation cost reduction does not have a direct effect on technology adoption. Trade liberalization affects technology cutoff only indirectly through
marginal cost advantage of high technology. As liberalization enhance the skill premium paid by firms, the marginal cost advantage of high technology falls leading less firms to upgrade their technology. However, overall effects of trade liberalization on wages, unemployment, wage inequality and relative unemployment rates remain the same.

5 Conclusion

In this model, we study the effects of trade liberalization on wages and unemployment rates of skilled and unskilled through skill biased technological change. The results of the analysis suggests that independent of the size of exporting and technology adoption costs, globalization, in the long run, increases the wages of both skilled and unskilled to increase. This results in an increase in overall wages. Also, unemployment rates for skilled and unskilled decreases due to a reduction in variable trade costs, such as tariffs and transportation costs, leading industry unemployment to decrease. Liberalization affects skilled and unskilled workers asymmetrically when countries have identical characteristics. Since reductions in tariffs or transportation costs increases wage of skilled more than unskilled, wage inequality rises. Finally, trade liberalization results in a change in the composition of unemployment pool. Both skilled and unskilled unemployment falls whereas unemployment rate of skilled falls more than unskilled.
Appendix

A.1 - The Derivation of Wage and Job Creation Curves

Let $E(\ell, \varphi)$ and $E(h, \varphi)$ be values of being employed to unskilled and skilled labor, respectively. $U_{\ell}$ and $U_{h}$ are values of being unemployed to unskilled and skilled labor, respectively. On the firm side, $\frac{\partial J(\ell|\varphi)}{\partial \ell}$ and $\frac{\partial J(h|\varphi)}{\partial h}$ are values of one more vacancy to low technology and high technology firms, respectively.

Nash bargaining between low-tech firms and unskilled labor can be expressed as follows

$$(1 - \beta)[E(\ell, \varphi) - U_{\ell}] = \beta \frac{\partial J(\ell|\varphi)}{\partial \ell}$$ \hspace{1cm} (58)

Expected value of being employed for unskilled is the sum of wage the worker receives and the value of becoming unemployed if the match is broken with probability $s$

$$rE(\ell, \varphi) = w_{\ell}(\varphi) + s[U_{\ell} - E(\ell, \varphi)]$$ \hspace{1cm} (59)

Rearranging (59) gives

$$[E(\ell, \varphi) - U_{\ell}] = \frac{w_{\ell}(\varphi) - rU_{\ell}}{r + s}$$ \hspace{1cm} (60)

From the first order condition of low-tech firm’s optimization problem (10) we know that

$$\frac{\partial J(\ell|\varphi)}{\partial \ell} = \frac{\partial J(\ell'|\varphi)}{\partial \ell'}$$ \hspace{1cm} (61)

Then, the shadow value of unskilled worker to low-tech firm (11) can be rewritten as

$$\frac{\partial J(\ell|\varphi)}{\partial \ell} = \frac{1}{r + s} \left\{ \frac{\partial r_{\ell}(\varphi)}{\partial \ell} - w_{\ell}(\varphi) - \frac{\partial w_{\ell}(\varphi)}{\partial \ell} l(\varphi) \right\}$$ \hspace{1cm} (62)

Substituting (60) and (62) into (58) yields

$$w_{\ell}(\varphi) = (1 - \beta) rU_{\ell} + \beta \frac{r_{\ell}(\varphi)}{\partial \ell} - \beta \frac{\partial w_{\ell}(\varphi)}{\partial \ell} l(\varphi)$$ \hspace{1cm} (63)

Similarly, Nash bargaining between a high tech firm and skilled labor is expressed as

$$(1 - \beta)[E(h, \varphi) - U_{h}] = \beta \frac{\partial J(h|\varphi)}{\partial h}$$ \hspace{1cm} (64)

Expected value of being employed for skilled is the sum of wage the worker receives and the value of becoming unemployed if the match is broken with probability $s$

$$[E(h, \varphi) - U_{h}] = \frac{w_{h}(\varphi) - rU_{h}}{r + s}$$ \hspace{1cm} (65)
Analogous to (62), the shadow value of skilled worker to high-tech firm is

\begin{equation}
\frac{\partial J(h|\varphi)}{\partial h} = \frac{1}{r+s} \left\{ \frac{r_h(\varphi) - w_h(\varphi)}{\partial h} - \frac{\partial w_h(\varphi)}{\partial h} \right\} h(\varphi)
\end{equation} (66)

Substituting (65) and (66) into (64) yields

\begin{equation}
w_h(\varphi) = (1 - \beta) r U_h + \beta \frac{\partial r_h(\varphi)}{\partial h} - \beta \frac{\partial w_h(\varphi)}{\partial h} h(\varphi)
\end{equation} (67)

Equations (63) and (67) are linear differential equations in \( \ell(\varphi) \) and \( h(\varphi) \), respectively. Using a similar method with Ebell and Haefke (2009) one can verify that

\begin{equation}
w_\ell(\varphi) = (1 - \beta) r U_\ell + \beta \frac{\partial r_\ell(\varphi)}{\partial \ell} \frac{\sigma}{\sigma - \beta}
\end{equation} (68)
solves (63) and

\begin{equation}
w_h(\varphi) = (1 - \beta) r U_h + \beta \frac{\partial r_h(\varphi)}{\partial h} \frac{\sigma}{\sigma - \beta}
\end{equation} (69)
solves (67)\(^{13}\)

First we will derive Wage and Job Creation Curves for unskilled labor. Substituting (3) into (68) and differentiating with respect to \( \ell \) yields

\begin{equation}
\frac{\partial w_\ell(\varphi)}{\partial \ell} = -\frac{1}{\sigma} \left( \beta \frac{\partial r_\ell(\varphi)}{\partial \ell} \frac{\sigma}{\sigma - \beta} \right)
\end{equation} (70)

Replacing (70) in (12) gives

\begin{equation}
w_\ell(\varphi) = \frac{\partial r_\ell(\varphi)}{\partial \ell} \frac{\sigma}{\sigma - \beta} - \frac{c}{m(\theta \ell)} \frac{r + s}{1 - \delta}
\end{equation} (71)

Substituting (68) into (71) yields

\begin{equation}
w_\ell(\varphi) = r U_\ell + \frac{\beta}{1 - \beta} \frac{c}{m(\theta \ell)} \frac{r + s}{1 - \delta}
\end{equation} (72)

Equation (72) suggests that wages are constant across low-tech firms. The discounted value of being unemployed for unskilled labor is the sum of unemployment compensation \( b \bar{w}_\ell \) and the expected returns from finding a job:

\begin{equation}
r U_\ell = b \bar{w}_\ell + \theta \ell m(\theta \ell) [E(\ell, \varphi) - U_\ell]
\end{equation} (73)

Substituting (60) and (72) into (73) reads

\begin{equation}
r U_\ell = b \bar{w}_\ell + \frac{\beta}{1 - \beta} \frac{c \theta \ell}{1 - \delta}
\end{equation} (74)

Since wages are constant across low-tech firms, substituting (74) into (72) yields Wage curve for unskilled labor.
workers:

\[ w_\ell(\varphi) = \frac{\beta}{1 - \beta} \frac{1}{1 - \beta} \frac{c}{1 - \delta} \left[ \theta_\ell + \frac{r + s}{m(\theta_\ell)} \right] \]  

(75)

The pricing rule for low-tech firms reads

\[ \frac{\partial R_\ell(\varphi)}{\partial \ell} = p_\ell^d(\varphi)\frac{\sigma - 1}{\sigma} \]  

(76)

and by constancy of wages across low technology firms, \(71\) suggests that

\[ p_\ell^d(\varphi_1)\varphi_1 = p_\ell^d(\varphi_2)\varphi_2 = p_\ell^d(\bar{\varphi}_\ell)\bar{\varphi}_\ell \]  

(77)

where \(\bar{\varphi}_\ell\) is the average productivity of low technology firms. Consequently, inserting (76) into (71) gives Job Creation curve for low technology firms:

\[ w_\ell(\varphi) = \frac{\sigma - 1}{\sigma - \beta} p_\ell^d(\bar{\varphi}_\ell)\bar{\varphi}_\ell - \frac{c}{m(\theta_\ell)} \frac{r + s}{1 - \delta} \]  

(78)

Similar steps are followed to derive Wage and Job Creation Curves for skilled labor. Substituting (3) into (69) and differentiating with respect to \(h\) yields

\[ \frac{\partial w_h(\varphi)}{\partial h} = -\frac{1}{\sigma} \left( \beta \frac{\partial r_h(\varphi)}{\partial h} \frac{\sigma}{\sigma - \beta} \right) \]  

(79)

Replacing (79) in (18) reads

\[ w_h(\varphi) = \frac{\partial r_h(\varphi)}{\partial h} \frac{\sigma}{\sigma - \beta} - \frac{c}{m(\theta_h)} \frac{r + s}{1 - \delta} \]  

(80)

Substituting (69) into (80) gives

\[ w_h(\varphi) = rU_h + \frac{\beta}{1 - \beta} \frac{c}{m(\theta_h)} \frac{r + s}{1 - \delta} \]  

(81)

Equation (81) suggests that wages are constant across high-tech firms. The discounted value of being unemployed for skilled labor is

\[ rU_h = b\bar{w}_h + \theta_h m(\theta_h) [E(l, \varphi) - U_h] \]  

(82)

Inserting (65) and (81) in (82) yields

\[ rU_h = b\bar{w}_h + \frac{\beta}{1 - \beta} \frac{c\theta_h}{1 - \delta} \]  

(83)

Since wages are constant across high-tech firms, substituting (83) into (81) gives Wage curve for skilled workers:

\[ w_h(\varphi) = \frac{\beta}{1 - \beta} \frac{1}{1 - \beta} \frac{c}{1 - \delta} \left[ \theta_h + \frac{r + s}{m(\theta_h)} \right] \]  

(84)
The pricing rule for high-tech firms reads

$$\frac{\partial r_h(\varphi)}{\partial h} = p^d_h(\varphi) \frac{\sigma - 1}{\sigma}$$ \hspace{1cm} (85)

By constancy of wages across high technology firms, (80) suggests that

$$p^d_h(\varphi_1) \varphi_1 = p^d_h(\varphi_2) \varphi_2 = p^d_h(\bar{\varphi}_h) \bar{\varphi}_h$$ \hspace{1cm} (86)

where $\bar{\varphi}_h$ is the average productivity of high-tech firms. Therefore, replacing (85) in (80) gives the Job Creation curve for high technology firms:

$$w_h(\varphi) = \frac{\sigma - 1}{\sigma - \beta} p^d_h(\bar{\varphi}_h) \bar{\varphi}_h - \frac{c}{m(\theta_h)} \frac{r + s}{1 - \delta}$$ \hspace{1cm} (87)

A.2 - The Entry Cutoff

Inserting (44), (45) and (46) into (42) yields

$$f_e = (\varphi^*_d)^{-k} \frac{\Pi}{r + \delta}$$ \hspace{1cm} (88)

where

$$\frac{\Pi}{r + \delta} = \frac{\Pi^d}{r + \delta} + \frac{\varphi^*_x}{\bar{\varphi}^*_d} \frac{\Pi^x}{r + \delta} + \frac{\varphi^*_h}{\bar{\varphi}^*_d} \frac{\Pi^h}{r + \delta}$$ \hspace{1cm} (89)

Average profit of a low-tech firms producing for only domestic market is

$$\frac{\Pi^d}{r + \delta} = \int_{\varphi^*_d}^{\varphi^*_x} \frac{\Pi^d}{r + \delta} \frac{g(\varphi)}{1 - G(\varphi_d)} d\varphi$$ \hspace{1cm} (90)

whereas average profit of a low-tech firm serving for both markets is

$$\frac{\Pi^x}{r + \delta} = \int_{\varphi^*_x}^{\varphi^*_z} \frac{\Pi^x}{r + \delta} \frac{g(\varphi)}{1 - G(\varphi^*_x)} d\varphi$$ \hspace{1cm} (91)

Finally, average profit of a high-tech firm serving for both market is

$$\frac{\Pi^h}{r + \delta} = \int_{\varphi^*_h}^{\varphi^*_z} \frac{\Pi^h}{r + \delta} \frac{g(\varphi)}{1 - G(\varphi^*_h)} d\varphi$$ \hspace{1cm} (92)

Using these average profit equations, FE condition can be written as

$$f_e = (\varphi^*_d)^{-k} \left[ \int_{\varphi^*_d}^{\varphi^*_x} \frac{\Pi^d}{r + \delta} \frac{g(\varphi)}{1 - G(\varphi_d)} d\varphi + \int_{\varphi^*_x}^{\varphi^*_z} \frac{\Pi^x}{r + \delta} \frac{g(\varphi)}{1 - G(\varphi^*_x)} d\varphi + (\varphi^*_d)^{-k} \int_{\varphi^*_h}^{\varphi^*_x} \frac{\Pi^h}{r + \delta} \frac{g(\varphi)}{1 - G(\varphi^*_h)} d\varphi \right]$$ \hspace{1cm} (93)
Inserting (26), (28), (30) and (32) into (93) yields

\[ \varphi_d^* = \Psi^1 \left[ f_\ell + \rho_x f_x + (\eta - 1)\rho_h f_\ell \right]^1 \]  

where

\[ \Psi = \left[ \frac{r + 1}{r + \delta k - \sigma + 1 f_\ell} \right] \]  

(94)

A.3 - Comparative Statics

A.3.1 - The Effects of Trade Liberalization on \( \theta_\ell \) and \( \theta_h \)

1. A reduction in \( \tau \) increases labor market tightness of both skill groups: \( \frac{\partial \theta_\ell}{\partial \tau} < 0 \) and \( \frac{\partial \theta_h}{\partial \tau} < 0 \).

Labor market clearing conditions for unskilled and skilled workers are

\[ LC_\ell(\theta_\ell, \theta_h) = LD_\ell(\theta_\ell, \theta_h) - LS_\ell(\theta_\ell, \theta_h) = 0 \]  

(95)

\[ \frac{A}{\beta \theta_\ell} \left[ 1 + \frac{\rho_x f_x}{f_\ell} - \frac{\rho_h (\eta - 1)}{\lambda^{\sigma - 1} - 1} \right] - \frac{m_0 \theta_\ell^{1-\alpha}}{s + m_0 \theta_\ell^{1-\alpha}} (1 - \rho_s) L = 0 \]  

(96)

\[ LC_h(\theta_\ell, \theta_h) = LD_h(\theta_\ell, \theta_h) - LS_h(\theta_\ell, \theta_h) = 0 \]  

(97)

\[ \frac{A}{\beta \theta_h} \left[ \frac{\rho_h (\eta - 1) \lambda^{\sigma - 1} - 1}{\lambda^{\sigma - 1} - 1} \right] - \frac{m_0 \theta_h^{1-\alpha}}{s + m_0 \theta_h^{1-\alpha}} \rho_s L = 0 \]  

(98)

where

\[ A = \frac{(r + 1) (\sigma - 1) (1 - b) k f_\ell}{(k - \sigma + 1) c} \]  

(99)

Taking the total derivative of both labor market clearing conditions with respect to \( \tau \) yields

\[ \frac{\partial LC_\ell}{\partial \theta_\ell} \frac{d \theta_\ell}{d \tau} + \frac{\partial LC_h}{\partial \theta_\ell} \frac{d \theta_\ell}{d \tau} + \frac{\partial LC_\ell}{\partial \theta_h} \frac{d \theta_h}{d \tau} + \frac{\partial LC_h}{\partial \theta_\ell} \frac{d \theta_\ell}{d \tau} = 0 \]  

(100)

Note that skilled labor market tightness \( \theta_h \) affects unskilled labor market only through the marginal cost advantage of high technology \( \lambda \). Taking the total derivative of (96) with respect to \( \tau \) produces the following equation.

\[ -X_\ell \frac{d \theta_\ell}{d \tau} - Z_\ell \frac{d \theta_h}{d \tau} = T_\ell \]  

(101)

where

\[ X_\ell = A(k - \sigma + 1) \frac{\rho_h (\eta - 1)}{(\lambda^{\sigma - 1} - 1)^2} \lambda^{\sigma - 2} \frac{\partial \lambda}{\partial \theta_\ell} \frac{\beta \theta_\ell}{\beta \theta_\ell^2} + \frac{1}{m_0 \theta_\ell^{1-\alpha}} \]
+ \frac{m_0 \theta^\alpha}{s + m_0 \theta^\alpha} (1 - \rho_s) \left[ \frac{\theta (\beta + (1 - b + b\beta)(r + s)\rho_{1-\alpha} + s(1 - \alpha) \right]}{s + m_0 \theta^\alpha} > 0 \right) 

Z_\ell = A(k - \sigma + 1) \frac{\rho_h (\eta - 1)}{(\lambda^\sigma - 1)^2} \lambda^{\sigma - 2} \frac{\partial \lambda}{\partial \theta_\ell} + \frac{1}{\beta \theta_\ell + \frac{(1 - b + b\beta)(r + s)}{m_0 \theta^\alpha}} < 0 \right) 

T_\ell = A \frac{k}{\tau} \left[ \frac{\rho_h (\eta - 1) \tau^{1 - \sigma}}{(\lambda^\sigma - 1)(\tau^{1 - \sigma} + 1)} \right] + \frac{\lambda^{\sigma - 2} \frac{\partial \lambda}{\partial \theta_\ell} + \frac{1}{m_0 \theta^\alpha}}{s + m_0 \theta^\alpha} > 0 \right) 

Total derivation of skilled labor market clearing condition with respect to \( \tau \) yields

\frac{\partial LC_h}{\partial \theta_\ell} \frac{\partial \lambda}{\partial \theta_\ell} \frac{d\theta_\ell}{d\tau} + \frac{\partial LC_h}{\partial \theta_h} \frac{d\theta_h}{d\tau} + \frac{\partial LC_h}{\partial \theta} \frac{d\lambda}{d\tau} + \frac{\partial LC_h}{\partial \tau} = 0 \right) 

Akin to (105), the effect of unskilled tightness(\( \theta_\ell \)) on skilled labor market is only through the marginal cost advantage of high technology (\( \lambda \)). Using (108) and taking the total derivative with respect to \( \tau \) produces the following equation.

\frac{X_h}{d\theta_\ell/d\tau} + \frac{Z_h}{d\theta_h/d\tau} = T_h \right) 

where

\frac{X_h}{A} = \frac{\rho_h (\eta - 1)}{(\lambda^\sigma - 1)^2} \lambda^{\sigma - 2} \frac{\partial \lambda}{\partial \theta_\ell} + \frac{1}{\beta \theta_\ell + \frac{(1 - b + b\beta)(r + s)}{m_0 \theta^\alpha}} \left[ (\sigma - 1) + \frac{(k - \sigma + 1)\lambda^{\sigma - 1}}{\lambda^\sigma - 1 - 1} \right] > 0 \right) 

\frac{Z_h}{A} = \frac{\rho_h (\eta - 1)}{(\lambda^\sigma - 1)^2} \lambda^{\sigma - 2} \frac{\partial \lambda}{\partial \theta_h} + \frac{1}{\beta \theta_h + \frac{(1 - b + b\beta)(r + s)}{m_0 \theta^\alpha}} \left[ (\sigma - 1) + \frac{(k - \sigma + 1)\lambda^{\sigma - 1}}{\lambda^\sigma - 1 - 1} \right] > 0 \right) 

\frac{T_h}{A} = \frac{k}{\tau} \left[ \frac{\rho_h (\eta - 1)\lambda^{\sigma - 1}}{(\lambda^\sigma - 1 - 1)(\tau^{1 - \sigma} + 1)} \right] + \frac{1}{\beta \theta_h + \frac{(1 - b + b\beta)(r + s)}{m_0 \theta^\alpha}} > 0 \right) 

From (101) and (106), we know that

\frac{d\theta_h}{d\tau} = \frac{T_h}{X_h} + \frac{T_h}{X_h} \frac{d\theta_t}{d\tau} \right) 

\frac{d\theta_t}{d\tau} = \frac{T_h}{X_h} - \frac{Z_h}{X_h} \frac{T_h}{X_h} + \frac{Z_h}{X_h} \frac{d\theta_t}{d\tau} \right) 

After some algebra one can show that both \( \frac{d\theta_h}{d\tau} \) and \( \frac{d\theta_t}{d\tau} \) are lower than zero.

2. A reduction \( \tau \) increases \( \theta_h \) more than \( \theta_t \): \( |\frac{d\theta_h}{d\tau}| > |\frac{d\theta_t}{d\tau}| \).
In order to prove that $\theta_{\ell}$: $|\frac{d\theta_{h}}{d\tau}| > |\frac{d\theta_{l}}{d\tau}|$, it is sufficient to show

$$\frac{T_h}{X_h} + \frac{T_{\ell}}{X_{\ell}} - \frac{Z_h}{X_h} - \frac{Z_{\ell}}{X_{\ell}} < \frac{T_h}{X_h} + \frac{T_{\ell}}{X_{\ell}}$$

This inequality boils down to

$$\frac{\tau^{1-\sigma}}{\tau^{1-\sigma} + 1} + \rho_x f_x f_{\ell} \left( \frac{\tau^{1-\sigma} - 1}{\tau^{1-\sigma} + 1} \right) < 0$$

which can be proved by $\varphi_x^* > \varphi_d^*$.

3. Skill premium paid by firms increases and marginal cost advantage of high technology decreases due to a reduction in $\tau$.

Since $|\frac{d\theta_{h}}{d\tau}| > |\frac{d\theta_{l}}{d\tau}|$, Note that the marginal cost advantage of high technology is a function of relative labor market frictions

$$\lambda = \frac{\gamma}{\beta\theta_h + \frac{(1-b+\beta)(r+s)}{m(\theta_h)}}$$

falls due to liberalization.

A.3.2 - The Effects of Trade Liberalization on Probabilities of Exporting and Technology Adoption

1. The probability of exporting: $\rho_x$

A reduction in $\tau$ has only a direct effect on the probability of exporting. Since $\rho_x$ is defined as

$$\rho_x = \frac{1 - G(\varphi_x^*)}{1 - G(\varphi_d^*)} = \left( \frac{\varphi_x^*}{\varphi_d^*} \right)^{-k} = \left( \frac{f_x}{f_{\ell}} \right) \frac{-k}{\tau^{-k}}$$

It is directly seen that $\frac{\partial\rho_x}{\partial\tau} < 0$.

2. The probability of technology adoption: $\rho_h$

Direct Effect: A reduction in $\tau$ increases the probability of technology adoption: $\rho_h$. 

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We have defined $\rho_h$ as:

$$\rho_h = \frac{1 - G(\varphi^*_h)}{1 - G(\varphi^*_d)} = \left( \frac{\varphi^*_h}{\varphi^*_d} \right)^{-k} = \left[ \frac{\eta - 1}{(\tau^{1-\sigma} + 1)(\lambda \sigma - 1)} \right]^{-\frac{k}{\sigma-1}}$$  \tag{116}$$

Equation (116) implies that $\frac{\partial \rho_h}{\partial \tau} < 0$.

**Indirect Effect:** We have shown that liberalization increases the skill premium paid by firms and consequently reduces the marginal cost advantage of high technology ($\lambda$). A reduction in $\lambda$ decreases the probability of technology adoption: $\rho_h$. Again, this can be seen from (116): $\frac{\partial \rho_h}{\partial \lambda} > 0$. Therefore, indirect effect moves Labor Demand of skilled in opposite direction.

**Net Effect:** From labor market clearing conditions (96) and (96), we can write the relative demand for unskilled as

$$\frac{LD_{\ell}}{LD_h} = 1 + \frac{\rho_x f_{\ell}}{\rho_x (\lambda \sigma - 1)}$$

We have shown that $|\frac{d \rho_x}{d \tau}| > |\frac{d \rho_h}{d \tau}|$. Therefore, the relative demand for unskilled falls due to liberalization: $\frac{\partial}{\partial \tau} \left( \frac{LD_{\ell}}{LD_h} \right)$. Note that $\rho_x$ increases and $\lambda$ falls due to liberalization. Therefore, $\rho_h$ must be increasing to after a reduction $\tau$ for relative demand for unskilled to fall.

**A.3.3 - The Effects of Trade Liberalization on Cutoff Productivities**

1. **Exporting Cutoff: $\varphi^*_x$**

We know that probability for exporting is $\rho_x = \left( \frac{\varphi^*_x}{\varphi^*_d} \right)^{-k}$. Inserting entry cutoff (47) into the exporting cutoff reads

$$\left( \varphi^*_x \right) = \Psi \left[ \frac{f_{\ell}}{\rho_x} f_x + (\eta - 1) \frac{\rho_h}{\rho_x} f_{\ell} \right]^\frac{1}{k}$$  \tag{118}$$

Note that

$$\frac{\rho_h}{\rho_x} = \left[ \frac{\tau^{1-\sigma} f_{\ell}}{1 + \tau^{1-\sigma} f_x \lambda^{\sigma - 1} - 1} \right]^{-\frac{k}{\sigma-1}}$$  \tag{119}$$

As $\tau$ falls, lambda decreases and $\frac{\tau^{1-\sigma}}{1 + \tau^{1-\sigma} \lambda^{\sigma - 1}}$ increases. Hence, the ratio of probabilities in (119) falls. We have shown that $\rho_x$ rises as $\tau$ falls. Consequently, the exporting cutoff falls.

2. **Technology Cutoff: $\varphi^*_h$**

We know that probability for technology adoption is $\rho_h = \left( \frac{\varphi^*_h}{\varphi^*_d} \right)^{-k}$. Inserting entry cutoff (47) into the technology cutoff reads

$$\left( \varphi^*_h \right) = \Psi \left[ \frac{f_{\ell}}{\rho_h} + \frac{\rho_x}{\rho_h} f_x + (\eta - 1) f_{\ell} \right]^\frac{1}{k}$$  \tag{120}$$
The derivative of the technology cutoff with respect to $\tau$ gives

$$\frac{\partial \varphi^*_h}{\partial \tau} = \left[ \frac{f_x}{\rho_h} + \frac{\rho_x}{\rho_h} f_x + (\eta - 1) f_{\ell} \right] \left[ \frac{\partial \rho_x}{\partial \tau} \rho_h - \frac{\partial \rho_h}{\partial \tau} \rho_x f_x - \frac{1}{\rho_h^2} \frac{\partial \rho_h}{\partial \tau} f_{\ell} \right]$$

(121)

To demonstrate $\frac{\partial \varphi^*_h}{\partial \tau} > 0$ we need to show that

$$\frac{\partial \rho_x}{\partial \tau} \rho_h f_x > \frac{\partial \rho_h}{\partial \tau} \left( \rho_x \frac{f_x}{f_{\ell}} + 1 \right)$$

(122)

We know that $\frac{\partial \rho_x}{\partial \tau} < 0$ and $\frac{\partial \rho_h}{\partial \tau} < 0$. Also, since $\frac{\partial \left( \frac{\rho_h}{\rho_x} \right)}{\partial \tau} < 0$, we can show that $|\frac{\partial \rho_x}{\partial \tau}| > |\frac{\partial \rho_h}{\partial \tau}|$. Then, in order to demonstrate $\frac{\partial \varphi^*_h}{\partial \tau} > 0$, it is sufficient to show $\rho_h \frac{f_x}{f_{\ell}} < \rho_x \frac{f_x}{f_{\ell}} + 1$. We know that $\varphi^*_x < \varphi^*_h$, then $\rho_x > \rho_h$. Now we can show that

$$\rho_h \frac{f_x}{f_{\ell}} < \rho_x \frac{f_x}{f_{\ell}} < \rho_x \frac{f_x}{f_{\ell}} + 1$$

(123)

Therefore, a reduction in $\tau$ leads technology cutoff to fall: $\frac{\partial \varphi^*_h}{\partial \tau} > 0$.

3. **Entry Cutoff: $\varphi^*_h$**

1. **Direct Effect:** A reduction $\tau$ increases the cutoff for entry: $\frac{\partial \varphi^*_d}{\partial \tau} < 0$.

Also, since $\rho_x$ and $\rho_h$ increases due to liberalization, (118) implies that $\frac{\partial \varphi^*_d}{\partial \rho_h} < 0$. Consequently, the probability for entry $\rho_e = 1 - G(\varphi^*_d) = (\varphi^*_d)^{-k}$ falls: $\frac{\partial \rho_e}{\partial \tau} > 0$.

2. **Indirect Effect:** A reduction $\lambda$ reduces the entry cutoff: $\varphi^*_d$.

After liberalization $\rho_h$ decreases due to a fall in $\lambda$. Entry cutoff (118) implies that $\frac{\partial \varphi^*_d}{\partial \rho_h} > 0$. This result suggest that indirect effect of trade liberalization reduces the cutoff for entry $\frac{\partial \varphi^*_d}{\partial \lambda} > 0$. Consequently, the probability for entry $\rho_e = 1 - G(\varphi^*_d) = (\varphi^*_d)^{-k}$ rises: $\frac{\partial \rho_e}{\partial \lambda} > 0$. However, we know that direct effect dominates for $\rho_h$. Therefore, the entry cutoff rises and the probability of entering ($\rho_e$) falls after a liberalization policy.
References


