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Labor Mismatch and Skill Premia

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Contrary to the predictions of the $2 \times 2 \times 2$ Heckscher–Ohlin model, empirical evidence shows that trade liberalization causes the skill premium to increase in some developing countries and to decrease in others. This paper develops a North–South model in which complex and simple goods are produced. The former is produced using skilled workers, while the latter is produced using skilled and unskilled workers. Labor markets feature search frictions. In this context, trade liberalization increases the skill premium in the North, while the impact on the skill premium in the South depends on skill abundance. The higher the skill abundance in a developing country, the higher the average productivity among skilled workers compared with unskilled workers. This leads to a higher employment of skilled workers in simple occupations, or labor mismatch. Therefore, the increase in the price of the simple good in the South, due to trade liberalization, leads to an increase in the wage of the mismatched workers. This offsets any negative impact on the skill premium caused by the decrease in the wage of skilled workers in complex occupations or the increase in the wage of unskilled workers in simple occupations. The opposite impact on the skill premium takes place in countries that are less skill abundant in the South. A threshold empirical estimation, on 50 developing and developed countries, shows that there is a statistically significant skill abundance threshold, below which the coefficient on the relationship between openness and wage inequality is negative and above which the estimate is positive.
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INTRODUCTION

The $2 \times 2 \times 2$ Heckscher–Ohlin model predicts that trade openness induces countries to export the good that intensively uses the relatively abundant factor of production, and to import the good that intensively uses the relatively scarce factor of production. Accordingly, skill-abundant developed countries are expected to export the good that intensively uses skilled workers. This contributes to an increase in the relative price of the skilled-intensive good, a rise in the relative demand for skilled workers, and consequently an increase in the skill premium. The model also predicts that skill-scarce developing countries are expected to export the good that intensively uses unskilled workers. This contributes to an increase in the relative price of the unskilled-intensive good, a rise in the relative demand for unskilled workers, and consequently a decrease in the skill premium. Theoretical predictions, however, are not supported by empirical evidence. Some developing countries experienced an increase in the skill premium after trade liberalization, while others witnessed a decrease in the skill premium after trade liberalization. This is documented by Hanson and Harrison [1995], Robbins [1996], Wood [1997], Freeman and Oostendorp [2000], and Goldberg

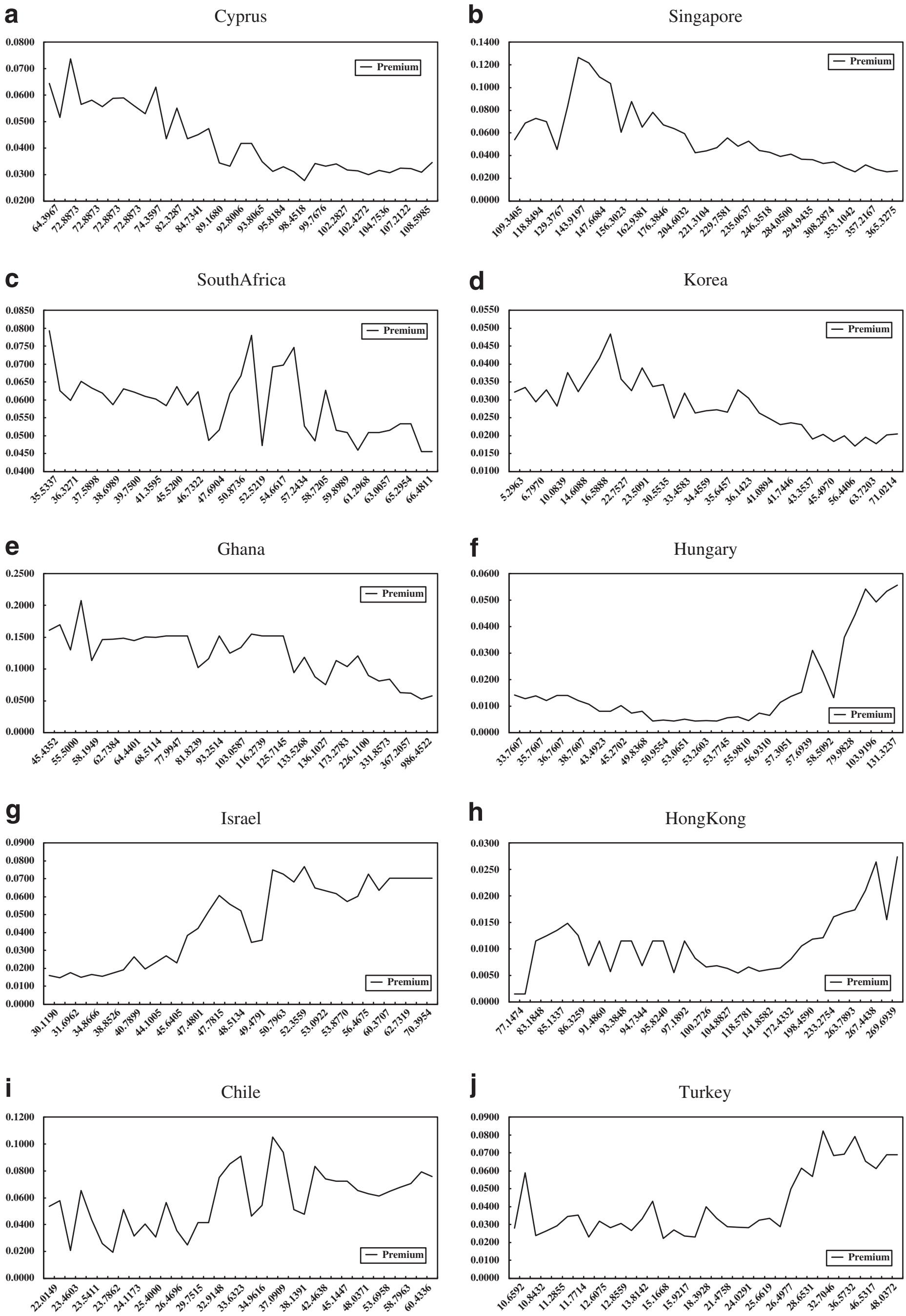

Figure 1. Openness and the skill premium in developing countries.

and Pavcnik [2004]. Figure 1 shows the relationship between trade openness and the skill premium in several developing countries.[1] Figures 1(a)–1(e) show the skill premium decreasing with trade openness in some countries, while Figures 1(f)–1(j) show the skill premium increasing with trade openness in other countries.

Several studies attempted to address this puzzle in order to resolve the inconsistency between the theoretical predictions and the empirical evidence. The first stream of studies attributed the increase in the skill premium in the South to outsourcing and technology transfer. For instance, Feenstra and Hanson [1995] argue that outsourcing shifts a portion of the input production from the North to the South. As this portion is the most skilled-intensive in the South, outsourcing increases skill demand and the skill premium in both countries. Similarly, Zhu [2004] and Zhu and Trefler [2005] argue that if the North loses competitiveness in unskilled-intensive products, a process of technology transfer is induced. This process implies that the production of the unskilled-intensive products is relocated to the South. The relocated goods are the most skilled-intensive by Southern standards. This Southern catchup raises the relative demand for skilled workers and exacerbates wage inequality.

Xu [2003] shows that, in a framework where there are non-traded goods whose range is endogenously determined by the level of trade barriers, a tariff reduction causes an expansion in the South's import range. This increases the demand for skilled workers in the North. The increase in the skilled labor cost in the North leads the South to expand its export range as well. The increase in the export ranges of both countries leads to an increase in skill demand and in the skill premium. Beaulieu et al. [2004] argue that a reduction in trade barriers within the high-tech sector can raise the demand for these products in both countries, and increase the demand for skilled labor and the skill premium.

Other studies argued that trade induces skill-biased technological change. Acemoglu [2002, 2003] shows that trade causes the relative price of skilled-intensive goods to increase in the North. The price increase makes the technologies used in the production of these goods more profitable to develop. This skill-biased technical change contributes to the increase in wage inequality in the North. Since the South imitates the North technologies that are becoming more skill-biased, it experiences an increase in the skill premium as well. Thoenig and Verdier [2003] argue that when globalization triggers an increased threat of technological leapfrogging, firms respond by biasing the direction of their innovations toward skilled-intensive technologies. Thus, openness causes defensive skill-biased technical change in the North and technical upgrading in the production of the imitated goods in the South toward more skilled-intensive ones. This causes an increase in wage inequality in the North and the South.

These studies provide insights into the factors generating an increase in the skill premium in developing and developed countries. However, they do not address the asymmetry of the response of the skill premium to trade openness within developing countries. This paper contributes to the literature by introducing a framework that features search frictions with heterogeneous workers and occupations. In this context, the paper develops a setup with two countries: the North and the South. In each country, the labor force is divided into skilled workers and unskilled workers. There are two types of final goods: a complex good and a simple good. The former is produced utilizing skilled workers. The latter is produced utilizing both skilled workers and unskilled workers. Labor markets in the two countries feature search frictions. There are two types of firms: those that produce complex goods and those that produce simple goods. The former post, complex vacancies, can be filled by skilled workers only. The latter post, simple vacancies, can be filled by both skilled workers and unskilled workers. This is motivated by the observation that developed and developing countries experience a high level of mismatch between the level of education of workers and the educational requirement of jobs they are occupying. This feature of the labor markets is referred to as overeducation. The introduction of the aspect of skill mismatch is justified by ample documented observations. The evidence on the incidence of overeducation across developed and developing countries is discussed in details in the next section.

Wages of the skilled workers in complex occupations, the skilled workers in simple occupations, and the unskilled workers in simple occupations are determined by a sharing rule as in Gautier [2002]. The skill premium is the ratio of the weighted average wage of all skilled workers to the wage of unskilled workers. Trade liberalization increases the skill premium in the North, while the impact on the skill premium in the South depends on the level of skill abundance. Developing countries that are relatively more skill abundant experience an increase in the skill premium after trade liberalization, while others that are less skill abundant experience a decrease in wage inequality. In the context of endogenous skill acquisition, the higher the skill abundance the higher the average productivity of skilled workers compared with unskilled workers. This higher skill bias leads to a higher employment of skilled workers in simple occupations, since they are more productive compared with unskilled workers. This implies that the increase in the price of the simple good in the South, due to trade liberalization, will have a positive impact on the skill premium through the increase in the wage of the skilled workers in simple occupations. If the proportion of this labor type is high, the increase in the price of the simple good leads to an increase in their total wage. This will offset any negative impact on the skill premium caused by the decrease in the wage of the skilled workers in complex occupations or the increase in the wage of the unskilled workers in simple occupations. The opposite impact on the skill premium takes place in countries that are less skill abundant in the South. Accordingly, the response of the skill premium to trade openness in developing countries is conditional upon skill abundance.

An empirical analysis is undertaken using the threshold estimation technique introduced by Hansen [1999]. The estimation results suggest the presence of a statistically significant skill abundance threshold, below which the coefficient estimate of the relationship between openness and wage inequality is significantly negative, and above which the point estimate is significantly positive. Thus, the empirical estimation provides evidence that supports the theoretical findings.

The remainder of the paper is organized as follows: the section 'Observations' presents the evidence on the incidence of overeducation, the section 'Model' presents the model, the section 'Estimation' includes the empirical estimation, the section 'Simulation' includes the simulation, the section 'Conclusion' includes the conclusion, and the section 'Appendix' includes the data and derivations appendices. References, tables, and figures are included thereafter.

OBSERVATIONS

Overeducation occurs when the educational qualifications of the worker is higher than the educational requirement of the job. Thus, an individual who has education in excess of that required to do the job is considered overeducated. The incidence of overeducation across developed and developing countries has been documented in several studies.[2] This evidence justifies the introduction of the aspect of overeducation in the model developed in this paper.

Several studies documented the incidence of overeducation in the United States. For instance, Duncan and Hoffman [1981] provide evidence from the Panel Study of Income Dynamics (PSID) that the incidence of overeducation reached 42 percent in 1976. Burris [1983] uses the National Sample Survey to show that 21.7 percent of full-time workers were overeducated in their current jobs in 1977–1978. Rumberger [1987] uses the Quality of Employment Survey to show that there were 27 percent overeducated workers in 1973 and 32 percent in 1977. Verdugo and Verdugo [1989] estimate a 10.9 percent overeducation in all occupations using the 1980 census. Sicherman [1991] uses the PSID waves of 1976 and 1978 to show that 40 percent of the workers in the sample report themselves are overeducated. Robst [1995] uses the PSID waves of 1976, 1978, and 1985 to show that 44.68 percent of the sample is overeducated. Cohn and Khan [1995] use the PSID to estimate a 33 percent incidence of overeducation in 1984. Daly et al. [2000] use the PSID to show that 38.5 percent of men and 36.8 percent of women were overeducated in 1976. The authors also provide evidence that 31.8 percent of men and 33.5 percent of women were overeducated in 1985.

Evidence on overeducation is also available for the United Kingdom. For instance, Groot (1996) uses the British Household Panel Survey to show that 13 percent of the males and 10 percent of the females were overeducated in 1991. Alpin et al. [1998] use the Labor Force Survey to show a 27 percent overeducation in 1995. Battu et al. [1999] use the Careers of Highly Qualified Workers Survey to show that, among the 1985 male graduates, overeducation reached 37.6 percent in 1986, 39.6 percent in 1991, and 41.5 percent in 1996. The authors also show that, among the 1985 female graduates, overeducation reached 46.4 percent in 1986, 39 percent in 1991, and 40.1 percent in 1996. Battu et al. [1999] also show that, among the 1990 male graduates, overeducation reached 41.6 percent in 1991 and 41.3 percent in 1996, while, among the 1990 female graduates, overeducation reached 45.3 percent in 1991 and 39.3 percent in 1996. Green et al. [1999] find 46 percent overeducation in 1998 according to the New Castle Survey, 29 percent overeducation in 1986 according to the Social Change and Economic Life Initiative, 32 percent overeducation in 1997 according to the UK Skills Survey, and 47.4 percent overeducation in 1995 according to the National Child Development Study. Dolton and Vignoles [2000] use the National Survey of Graduates and Diplomates to show that 38 percent of all graduates surveyed were overeducated in 1980, while 30 percent were overeducated in 1986. Chevalier and Lindley [2009] use the Careers of Highly Qualified Workers Survey to show that the male cohort in 1985 had overeducation of 13 percent, 33.83 percent, and 12.73 percent using three measures of overeducation. The author also shows that the female cohort in 1985 had overeducation of 18.88 percent, 33.82 percent, and 20.02 percent, using three measures of overeducation. Chevalier and Lindley [2009] also find that the male cohort in 1990 had overeducation of 14.68 percent, 30.87 percent, and 14.42 percent, while the female cohort in 1990 had overeducation of 21.57 percent, 30.93 percent, and 17.44 percent. Dolton and Silles [2001] use the New Castle Alumni Survey in 1998 to show that 22 percent of the graduates are overeducated for their jobs and 42 percent are overqualified for their first job. Mavromaras et al. [2007] use the British Workplace Employment Relations Survey 2004 to show that 31.9 percent have skills higher than needed in their job and 21.1 percent have skills much higher than needed.

In the developing world, the evidence on overeducation is not as abundant as in the developed world, due to the lack of detailed labor market data necessary to conduct such an analysis. However, some studies were able to provide evidence on overeducation in some developing countries. For instance, Cohn and Ng [2000] use the 1986 Hong Kong Census to show that 38 percent of the males and 32 percent of the females are overeducated. The authors also use the 1999 Hong Kong Census to show that 37 percent of the males and 31 percent of the females are overeducated. Hung [2008] and Tsay et al. [2005] use the Taiwan Social Change Survey in 1997 and 2002 to show that 45 percent of the workers are overeducated. Lin and Wang [2005] use the Survey of Family Income and Expenditure in Taiwan to show that the percentage of workers who are overeducated increased from 27 percent in 1993 to 35 percent in 1999. There is an evidence of overeducation in China as well. For instance, Mayston and Yang [2008] use a survey conducted by the Research Center for the Economics of Education at Peking University to show that 20.5 percent of the graduates across China reported themselves as being overeducated. The authors also show an 18.8 percent rate of overeducation for females and 21.5 percent for males. Xiangrong [2008] uses the Survey of National Income Distribution to show that 15.65 percent of the whole sample, 17.15 percent of all the males, and 14.03 percent of all the females in the sample are overeducated in 1995.

It is obvious that the evidence on overeducation in developing countries is not as abundantly available as in the developed world. However, it is reasonable to assume that the level of skill mismatch is higher in the developing countries, since the unemployment rate is higher than that in the developed world. This is because skilled workers accept unskilled jobs temporarily, to avoid unemployment, until they are matched with a skilled job. Since some developing countries have higher unemployment rates than others, the level of labor mismatch differs between developing countries as well.

MODEL

Assume there are two countries: the North and the South. The two countries are indexed by the subscript $i \in (N, S)$, respectively. In country i, the labor force is divided into skilled workers and unskilled workers. The North is relatively abundant in skilled labor, while the South is relatively abundant in unskilled labor. In country i, there are two types of firms: those that produce complex goods and those that produce simple goods. The former post complex vacancies that can be filled by skilled workers only. The latter post simple vacancies that can be filled by both skilled workers and unskilled workers. A skilled worker in a simple occupation is allowed to conduct on-the-job search for a complex occupation. The feature of on-the-job search is essential, as it allows skilled workers to accept a simple occupation temporarily and continue to search for a complex one.

Individuals

We follow Dinopoulos and Segerstrom [1999] and assume country i has N_i individuals indexed by their ability $a \in [0, 1]$. The distribution of abilities across individuals is uniform. Each individual knows his own ability, as do all firms that can potentially hire him. The lifetime of each individual is finite and given by $D > 0$. The frequency with which individuals are born and die is exogenous. Assume that N_0 individuals are born at each instant in time. When an individual dies, he is replaced by a new individual with the same ability. Thus, the country's population level is stationary and equals $N_i = DN_0$. These assumptions ensure that the economy's population is

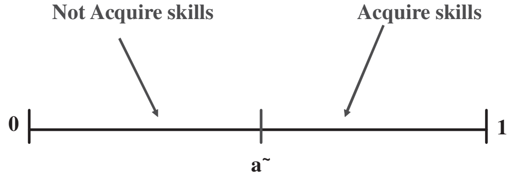

Figure 2. Threshold ability level.

stationary. An individual can enter the labor force as unskilled and earn the unskilled wage W_i^{ls} for the duration of his life D. Alternatively, an individual with ability a can enter the labor force after spending a given period of time $T<D$ in training to become skilled. A skilled worker with ability a earns a wage W_i^h, which is the average wage of all skilled workers for a period $D-T>0$. The worker does not earn any income during the period of training. The wages W_i^{ls} and W_i^h are determined later in a search framework. The training process does not require any real resources. Thus, the opportunity cost of becoming skilled equals the discounted value of the foregone unskilled wage. Therefore, an individual with ability a undergoes training to become a skilled worker if and only if

$$(1)\qquad \int_t^{t+D} e^{-\delta(s-t)} W_i^{ls} ds < \int_{t+T}^{t+D} e^{-\delta(s-t)} a W_i^h ds$$

where δ is the steady state discount rate. The left-hand side of the inequality equals the discounted wage of an unskilled worker earning W_i^{ls} from time t until death at time $t+D$. The right-hand side is the lifetime wage of a skilled worker. The skilled worker earns 0 income during the training period and aW_i^h from time $t+T$ until time $t+D$, discounted to time t. Since the right-hand side is increasing in ability a and the left-hand side is independent of a, there exists a threshold ability denoted $\tilde{a}_i$ such that (1) holds as an equality. Therefore, all individuals with ability $a>\tilde{a}_i$ choose to acquire skills, while those with ability $a\leqslant\tilde{a}_i$ choose not to acquire skills. Setting (1) as an equality yields the threshold ability level $\tilde{a}_i=(1-e^{-\delta D})/(e^{-\delta T}-e^{-\delta D})(1/\omega_i)$. Figure 2 shows the threshold ability level $\tilde{a}$.

Thus, an increase in the skill premium $\omega_i=W_i^h/W_i^{ls}$ reduces the fraction $\tilde{a}_i$ of individuals that choose not to become skilled. Consider the steady state supply of unskilled and skilled labor at time t. There are individuals who remain unskilled and is comprised of a fraction $\tilde{a}_i$ of the population. Thus, the supply of unskilled labor is $L_i(\omega_i)=\tilde{a}_i(\omega_i)N_i$. The supply of unskilled labor is decreasing in the skill premium since $\tilde{a}_i'(\omega_i)<0$. The remaining fraction $1-\tilde{a}_i$ makes up the two remaining groups: one consists of individuals engaged in training and the other consists of individuals who completed their training. Because N_0 individuals are born at each instant in time, the number of potential trainees consists of those younger individuals born between time t and $t-T$. Thus, the number of potential trainees is TN_0. Similarly, the number of potentially skilled workers consists of those older individuals born between time $t-D$ and $t-T$ and is equal to $(D-T)N_0$. Thus, the number of individuals in training is $(1-\tilde{a}_i)TN_0=(1-\tilde{a}_i)T/DN_i$, whereas the number of skilled workers equals $(1-\tilde{a}_i)(D-T)N_0=(1-\tilde{a}_i)(1-T/D)N_i$. The average ability of workers that completed training is $(1/2)+(\tilde{a}_i/2)$ and the supply of skilled labor measured in efficiency units is $H_i(\omega_i)=[N_i(1-\tilde{a}_i(\omega_i))(1-T/D)][(1+\tilde{a}_i(\omega_i))/2]=N_i\lambda(\omega_i)$.

Thus, the country's relative endowment of skilled labor is given by $H_i(\omega_i)/L_i(\omega_i) = \lambda(\omega_i)/\tilde{a}_i(\omega_i)$. This reveals that the relative endowment is independent of the population level N_i and is increasing in the skill premium since $\lambda'(\omega) > 0$ and $\tilde{a}'_i(\omega) < 0$. In this context, we assume that the productivity of the skilled workers is equal to their average ability given by $A_i^h = (1 + \tilde{a})/2$. Similarly, the productivity of the unskilled workers is given by their average ability $A_i^l = \frac{\tilde{a}}{2}$.

$H_i + L_i$ is considered the labor force in this economy, which we normalize to 1. Thus, the labor force in country i is of measure 1, and is divided into $\theta_I = (H_i/H_i + L_i)$ skilled and $(1-\theta_i) = (L_i/H_i + L_i)$ unskilled. Search frictions in the labor market allow for equilibrium unemployment. Therefore, the skilled and the unskilled household members are divided into those employed and those unemployed as follows

$$N_i^{hc} + N_i^{hs} + U_i^h = \theta_i \tag{2}$$

$$N_i^{ls} + U_i^l = 1 - \theta_i \tag{3}$$

Where N_i^{hc} is the number of skilled workers in complex occupations, N_i^{hs} is the number of skilled workers in simple occupations, and N_i^{ls} is the number of unskilled workers in simple occupations. U_i^h and U_i^l denote the number of the skilled unemployed and the unskilled unemployed in country i, respectively.

Firms

Firms in country i produce two goods: the complex good Y_i^c and the simple good Y_i^s. The aggregate production is given by a constant elasticity of substitution composite of the two goods as follows

$$Y_i = \left[\gamma\left(Y_i^s\right)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma)\left(Y_i^c\right)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{4}$$

Where $\varepsilon \in (0, \infty)$ is the elasticity of substitution between the two goods. $\gamma \in (0, 1)$ is a distribution parameter that determines the importance of the two goods in the aggregate production. The complex good in country i is produced using skilled workers only according to the following production function

$$Y_i^c = A_i^c\left(A_i^h N_i^{hc}\right)^{\beta} \tag{5}$$

The simple good in country i is produced using both unskilled workers and skilled workers according to the following production function

$$Y_i^s = A_i^s\left(A_i^l N_i^{ls} + A_i^h N_i^{hs}\right)^{\beta} \tag{6}$$

Where $\beta \in (0, 1)$. A_i^h is the skilled labor augmenting technology, A_i^l is the unskilled labor augmenting technology, A_i^c is the technology in the complex sector, and A_i^s is the technology in the simple sector. A_i^h/A_i^l is defined as the skill technological bias or the relative average productivity between skilled and unskilled workers. A_i^c/A_i^s is defined as the sector technological bias. The price of the complex good in country i is given by

$$P_i^c = (1-\gamma)\left(\frac{Y_i}{Y_i^c}\right)^{\frac{1}{\varepsilon}} \tag{7}$$

While the price of the simple good in country i is given by

$$P_i^s = \gamma\left(\frac{Y_i}{Y_i^s}\right)^{\frac{1}{\varepsilon}} \tag{8}$$

the price of the aggregate good in country i is normalized to 1 as follows

$$\left[(\gamma)^{\varepsilon}\left(P_i^s\right)^{1-\varepsilon}+(1-\gamma)^{\varepsilon}\left(P_i^c\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}=1 \tag{9}$$

Firms producing complex goods post complex vacancies V_i^cthat can be matched with skilled workers only. Firms producing simple goods post simple vacancies V_i^s that can be matched with both skilled workers and unskilled workers.

The skilled unemployed use a portion s_i of their time to search for a complex occupation and $(1-s_i)$ to search for a simple occupation. The unskilled unemployed use all their time to search for a simple occupation. The skilled workers in simple occupations can undertake on-the-job search with a search intensity of o_i. The matching functions are constant returns to scale, homogeneous of degree one, functions of the vacancies, and effective searchers as follows

$$M_i^c = m_i^c\left(V_i^c\right)^{\alpha_i}\left(s_i U_i^h + o_i N_i^{hs}\right)^{1-\alpha_i} \tag{10}$$

$$M_i^s = m_i^s\left(V_i^s\right)^{\alpha_i}\left((1-s_i)U_i^h + U_i^l\right)^{1-\alpha_i} \tag{11}$$

M_i^c and M_i^s represent the number of complex and simple occupation matches, respectively. α_i is the elasticity of matching with respect to vacancies. m_i^c and m_i^s are the efficiency parameters of the complex and simple matching processes, respectively. In this context, $\rho_i^c = M_i^c/(s_i U_i^h + o_i N_i^{hs})$ and $\rho_i^s = (M_i^s)/((1-s_i)U_i^h + U_i^l)$ are the endogenous probabilities that a searcher is matched with a complex or a simple occupation, respectively. Similarly, $q_i^c = M_i^c/V_i^c$ and $q_i^s = M_i^s/V_i^s$ are the endogenous probabilities that a complex or a simple vacancy is matched with a worker, respectively.

Wages

The standard approach to solve equilibrium search models is to attach an asset value to every possible worker and job state as in Gautier [2002]. The expected income stream for the skilled unemployed and the unskilled unemployed is denoted by $r\Omega_i^{Uh}$ and $r\Omega_i^{Ul}$, respectively. Furthermore, there are three possible employment states $r\Omega_i^{Ehc}$, $r\Omega_i^{Ehs}$, $r\Omega_i^{Els}$, three possible job states $r\Omega_i^{Fhc}$, $r\Omega_i^{Fhs}$, $r\Omega_i^{Fls}$, and three possible disagreement while bargaining states $r\Omega_i^{Dhc}$, $r\Omega_i^{Dhs}$ and $r\Omega_i^{Dls}$. The asset values for the unemployed are given by

$$r\Omega_i^{Uh} = b_i + \rho_i^c\left[\Omega_i^{Ehc} - \Omega_i^{Uh}\right] + \rho_i^s\left[\Omega_i^{Ehs} - \Omega_i^{Uh}\right] \tag{12}$$

$$r\Omega_i^{Ul} = b_i + \rho_i^s\left[\Omega_i^{Els} - \Omega_i^{Ul}\right] \tag{13}$$

Where b_i is the unemployment benefit. The expected incomes for employed workers can be expressed as

$$r\Omega_i^{Ehc} = W_i^{hc} - \chi_i^c\left[\Omega_i^{Ehc} - \Omega_i^{Uh}\right] \tag{14}$$

$$r\Omega_i^{Ehs} = W_i^{hs} + \rho_i^c\left[\Omega_i^{Ehc} - \Omega_i^{Ehs}\right] - \chi_i^s\left[\Omega_i^{Ehs} - \Omega_i^{Uh}\right] \tag{15}$$

$$r\Omega_i^{Els} = W_i^{ls} - \chi_i^s\left[\Omega_i^{Els} - \Omega_i^{Ul}\right] \tag{16}$$

where W_i^{hc}, W_i^{hs}, and W_i^{ls} denote the wages of the skilled workers in complex occupations, the skilled workers in simple occupations, and the unskilled workers in simple occupations, respectively. χ_i^c and χ_i^s denote the exogenous separation rates from complex and simple occupations, respectively. The asset values of the different matches from the firm's point of view are given by

$$r\Omega_i^{Fhc} = P_i^c\frac{\partial Y_i^c}{\partial N_i^{hc}} - W_i^{hc} - \chi_i^c\left[\Omega_i^{Fhc} - \Omega_i^{Vc}\right] \tag{17}$$

$$r\Omega_i^{Fhs} = P_i^s\frac{\partial Y_i^s}{\partial N_i^{hs}} - W_i^{hs} - \left(\chi_i^s + \rho_i^c\right)\left[\Omega_i^{Fhs} - \Omega_i^{Vs}\right] \tag{18}$$

$$r\Omega_i^{Fls} = P_i^s\frac{\partial Y_i^s}{\partial N_i^{ls}} - W_i^{ls} - \chi_i^s\left[\Omega_i^{Fls} - \Omega_i^{Vs}\right] \tag{19}$$

Finally, the three different disagreement payoffs in the bargaining state are given by

$$r\Omega_i^{Dhc} = b_i + \chi_i^c\left[\Omega_i^{Uh} - \Omega_i^{Dhc}\right] \tag{20}$$

$$r\Omega_i^{Dhs} = b_i + \rho_i^c\left[\Omega_i^{Ehc} - \Omega_i^{Dhs}\right] + \chi_i^s\left[\Omega_i^{Uh} - \Omega_i^{Dhs}\right] \tag{21}$$

$$r\Omega_i^{Dls} = b_i + \chi_i^s\left[\Omega_i^{Ul} - \Omega_i^{Dls}\right] \tag{22}$$

The model can be closed by assuming that vacancies are opened until the expected income stream is 0 as follows

$$r\Omega_i^{Vc} = q_i^c\left[\Omega_i^{Fhc} - \Omega_i^{Vc}\right] - C^c = 0 \tag{23}$$

$$r\Omega_i^{Vs} = q_i^s\left[U_i^l\Omega^{Fls} + U_i^h\Omega^{Fhs} - \Omega_i^{Vs}\right] - C^s = 0 \tag{24}$$

Where C^c and C^s denote the flow costs for complex and simple vacancies, respectively. We follow the literature in assuming that a realized match shares this surplus. Therefore, the wage of a skilled worker in a complex occupation in country i is given by[3]

$$W_i^{hc} = (1-\xi_i)b_i + \xi_i\left(P_i^c\frac{\partial Y_i^c}{\partial N_i^{hc}}\right) \tag{25}$$

Where ξ_i is the firm's share of the surplus. Similarly, the bargained wage of the skilled worker in a simple occupation is given by[4]

$$W_i^{hs} = (1-\xi_i)b_i + \xi_i\left(P_i^s\frac{\partial Y_i^s}{\partial N_i^{hs}}\right) \tag{26}$$

Finally, the bargained wage of the unskilled worker in a simple occupation is given by[5]

$$W_i^{ls} = (1-\xi_i)b_i + \xi_i\left(P_i^s \frac{\partial Y_i^s}{\partial N_i^{ls}}\right) \tag{27}$$

In all these cases, the wage is a weighted average of two terms: the first term indicates that the worker is compensated by a fraction $(1-\xi_i)$ for the foregone unemployment benefit. The second indicates that the worker is rewarded for a fraction ξ_i of the firm's revenues from the value of the worker's marginal productivity. Given these wages, the skill premium ω_i, in country i, is given by the ratio of the average wage of the skilled workers in both occupations $W_i^h = (N_i^{hc}W_i^{hc} + N_i^{hs}W_i^{hs})/(N_i^{hc} + N_i^{hs})$ to that of the unskilled workers, as follows

$$\omega_i = \frac{W_i^h}{W_i^{ls}} \tag{28}$$

In this context, the impact of trade liberalization on wage inequality in the South is described in the following proposition.

Proposition 1: *∃ a threshold skill bias, $\left(A_i^h/A_i^l\right)^*$, $i=S$, below which the skill premium decreases after trade liberalization, and above which the skill premium increases after trade liberalization.*

Proof. Included in Appendix section 'Proof of Proposition 1'.

This proposition provides a possible explanation for the observed patterns of skill premia in the South. As the skill bias is endogenized, the condition for the increase in the skill premium in the South can be determined in terms of skill abundance as well. In this context, A_i^h is assumed the average ability among skilled workers and A_i^l is assumed the average ability among unskilled workers. Then, the skill bias is related to skill abundance according to the following proposition.

Proposition 2: *The relative average productivity of skilled workers to unskilled workers, or the skill bias A_i^h/A_i^l, is increasing in relative skill abundance H_i/L_i.*

Proof. Included in Appendix section 'Proof of Proposition 2'.

In this context, Propositions 1 and 2 imply that there exists a threshold level of skill abundance $(H_i/L_i)^*$ in the South, $i=S$, below which countries experience a decrease in the skill premium after trade liberalization and above which countries experience an increase in the skill premium after trade liberalization. Figure 3 shows the threshold skill abundance. Therefore, developing countries that are more skill abundant experience an increase in the skill premium after trade liberalization, while others that are less skill abundant experience a decrease in the skill premium after trade liberalization. The higher the skill abundance in a developing country, the higher the average productivity of skilled workers compared with unskilled workers. This higher skill bias leads to a higher level of employment of skilled workers in simple occupations, since they are more productive relative to unskilled workers. This means that the increase in the price of the simple good, due to trade

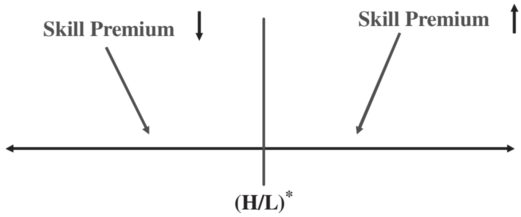

Figure 3. Threshold skill abundance.

liberalization, will have a positive impact on the skill premium through the increase in the wage of the skilled workers in simple occupations. If their proportion is high, the increase in the price of the simple good leads to an increase in their total wage. This increase offsets any negative impact on the skill premium caused by the decrease in the wage of the skilled workers in complex occupations or the increase in the wage of the unskilled workers in simple occupations. The opposite impact on the skill premium takes place in countries that are less skill abundant in the South. Accordingly, we see an asymmetric response of the skill premium to trade openness in developing countries, conditional upon skill abundance. As for the North, the following proposition applies.

Proposition 3: *The skill premium increases in the North after trade liberalization.*

Proof. Included in Appendix section 'Proof of Proposition 3'.

This is consistent with the observation that the skill premium increases in all developed countries after trade liberalization. Therefore, we can conclude that there is a threshold level of skill abundance below which all countries are developing. These developing countries experience a decrease in wage inequality after trade liberalization. Above this threshold, the remaining developing countries besides all developed countries experience an increase in wage inequality after trade liberalization. This conclusion is tested empirically in the following section. Finally, we have a relationship between the sector bias and the threshold skill bias as follows.

Proposition 4: *A higher sector bias A_i^c/A_i^s corresponds to a lower threshold skill bias $(A_i^h/A_i^l)^*$.*

Proof. Included in Appendix section 'Proof of Proposition 4'.

A higher sector bias in the South leads to a higher relative productivity of the skilled workers in complex occupations compared with the skilled workers in simple occupations. Accordingly, more of the skilled workers will be employed in the complex sector rather than in the simple sector. Therefore, a higher sector bias corresponds to a lower threshold skill bias. This implies that more countries in the South will experience an increase in the skill premium after trade liberalization.

ESTIMATION

In this section, the proposition, that the impact of trade openness on the skill premium depends on skill abundance, is tested empirically using the threshold estimation technique developed in Hansen [1999]. The threshold estimation model is given by

$$Premium_{it} = \begin{cases} \mu_i + \beta_1 Openness_{it} + \phi_1 Abundance_{it} + \phi_2 RGDP_{it} + e_{it} & \text{if } Abundance_{it} \leqslant \sigma \\ \mu_i + \beta_2 Openness_{it} + \phi_1 Abundance_{it} + \phi_2 RGDP_{it} + e_{it} & \text{if } Abundance_{it} > \sigma \end{cases} \quad (29)$$

where the subscript i indexes the country and the subscript t indexes time. The dependent variable $Premium_{it}$ denotes the skill premium in country i in year t. The variable $Openness_{it}$ is a measure of trade openness in country i in year t. The threshold variable $Abundance_{it}$ is a measure of skill abundance in country i in year t. The variable $RGDP_{it}$ denotes the logarithm of real gross domestic product (GDP) per capita in country i in year t, and is added to control for macroeconomic developments that might impact wage inequality. In this context, the observations are divided into two regimes depending on whether the threshold variable $Abundance_{it}$ is smaller or larger than the threshold σ. The regimes are distinguished by differing regression slopes, β_1 and β_2. Therefore, the threshold regression determines the existence and significance of a threshold skill abundance level in the relationship between trade liberalization and wage inequality rather than imposing *a priori* an arbitrary classification scheme. According to the predictions of the model, the coefficient β_1 is expected to be negative, while the coefficient β_2 is expected to be positive. As in Hansen [1999], another way of writing the equation of interest is

$$\begin{aligned} Premium_{it} = {} & \mu_i + \beta_1 Openness_{it} I(Abundance_{it} \leqslant \sigma) \\ & + \beta_2 Openness_{it} I(Abundance_{it} > \sigma) \\ & + \phi_1 Abundance_{it} + \phi_2 RGDP_{it} + e_{it}) \end{aligned} \quad (30)$$

where $I(.)$ is the indicator function. A balanced panel annual data is used for 50 developing and developed countries and cover the period from 1963 to 1999. A Theil index of wage inequality compiled by the University of Texas Inequality Project is used as a measure of the skill premium. Total trade as a percentage of real GDP from the Penn World Tables 6.2 is used as a measure of trade openness. As in Forbes [2001], the average years of total education in the population aged over 15, from Barro and Lee international data on educational attainment, is used as a measure of skill abundance. Finally, real GDP per capita is extracted from the Penn World Tables 6.2. Detailed data description is included in the appendix. Summary statistics of the variables used in the estimation are provided in Table 1.

To determine the number of thresholds, the model is estimated by least squares allowing for zero, one, two, and three thresholds. The test for a single threshold is significant, while the tests for a double and a triple threshold are not significant. Thus, we conclude that there is evidence for one threshold in the regression relationship. The point estimate of the threshold is 4.3686, and the asymptotic 99 percent

Table 1 Summary statistics

	Minimum	*25 percent quantile*	*Median*	*75 percent quantile*	*Maximum*
$Premium_{it}$	0.002854	0.016643	0.034113	0.061814	0.309261
$RGDP_{it}$	314.189371	3,610.208083	6,761.889464	14,692.647900	33,444.446450
$Openness_{it}$	5.296258	34.429837	53.695807	79.306409	986.452194
$Abundance_{it}$	0.804000	3.881400	5.808800	8.132800	12.017600

confidence interval is [4.2144, 4.4920]. More information can be learned from the plot of the concentrated likelihood ratio function displayed in Figure 4. From the first-step likelihood ratio function, we see that the threshold estimate is the point where the likelihood function equals 0. This occurs at $\sigma = 4.3686$.

The regression slope estimates, conventional OLS standard errors, and white-correlated standard errors are reported in Table 2. Real GDP per capita has a negative effect on wage inequality with a coefficient of −0.014630. Skill abundance has a positive impact on wage inequality with a coefficient of 0.003905. The estimates of primary interest are those on trade openness. Trade openness has a statistically significant negative effect on wage inequality, with a coefficient of −0.000140, if skill abundance is below the threshold 4.3686. On the other hand, trade openness has a positive impact on wage inequality, with a statistically significant coefficient of 0.000101, if skill abundance is above the threshold.

The same analysis is also conducted on a subsample of developing countries only. The test for a single threshold is significant, while the tests for a double and a triple threshold are not significant. Thus, we conclude that there is evidence for one threshold in the regression relationship. The point estimate of the threshold is 4.4930 and the asymptotic 99 percent confidence interval is [4.1458, 4.4930]. More information can be learned from the plot of the concentrated likelihood ratio

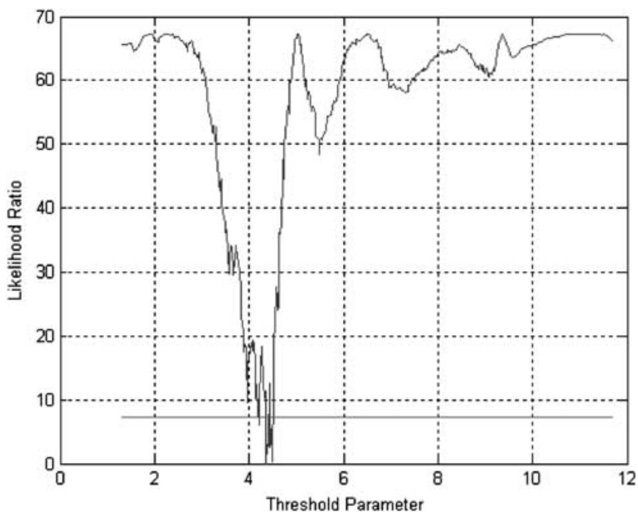

Figure 4. Confidence interval construction in single threshold model (entire sample).

Table 2 Regression estimates (entire sample)

Regressor	*Coefficient estimate*	*OLS standard error*	*White-correlated standard error*
$RGDP_{it}$	−0.014630*	0.003291	0.004053
$Abundance_{it}$	0.003905*	0.000932	0.000986
$Openness_{it}I\ (Abundance_{it} \leqslant 4.3686)$	−0.000140*	0.000022	0.000037
$Openness_{it}I\ (4.3686 < Abundance_{it})$	0.000101*	0.000028	0.000046

*implies a statistically significant coefficient.

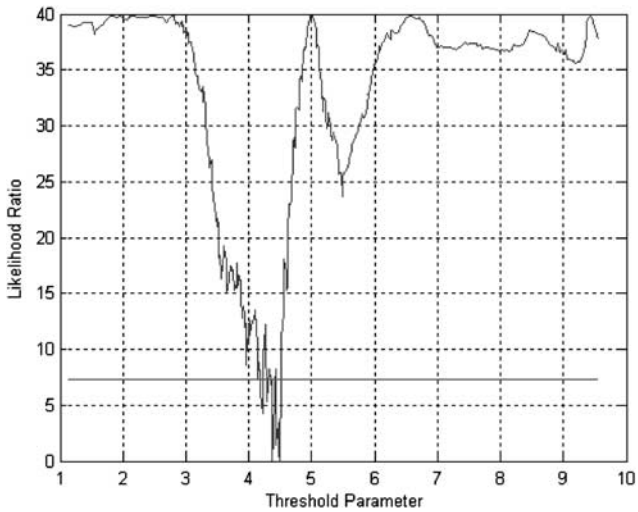

Figure 5. Confidence interval construction in single threshold model (developing countries subsample).

Table 3 Regression estimates (developing countries subsample)

Regressor	*Coefficient estimate*	*OLS standard error*	*White-correlated standard error*
$RGDP_{it}$	−0.018973*	0.004315	0.004658
$Abundance_{it}$	0.005166*	0.001296	0.001364
$Openness_{it}I$ ($Abundance_{it} \leqslant 4.493000$)	−0.000146*	0.000027	0.000036
$Openness_{it}I$ ($4.493000 < Abundance_{it}$)	0.000085*	0.000035	0.000047

*implies a statistically significant coefficient.

function displayed in Figure 5. From the first-step likelihood ratio function, we see that the threshold estimate is the point where the likelihood function equals 0. This occurs at $\sigma = 4.4930$. It is noteworthy that the threshold skill abundance in the entire sample is within the confidence interval of the threshold in the subsample.

The regression slope estimates, conventional OLS standard errors, and white-correlated standard errors are reported in Table 3. Real GDP per capita has a negative effect on wage inequality with a coefficient of −0.018973. Skill abundance has a positive impact on wage inequality with a coefficient of 0.005166. The estimates of primary interest are those on trade openness. Trade openness has a statistically significant negative effect on wage inequality, with a coefficient of −0.000146, if skill abundance is below the threshold 4.4930. On the other hand, trade openness has a positive impact on wage inequality, with a statistically significant coefficient of 0.000085, if skill abundance is above the threshold. Thus, the empirical estimations provide evidence to support the theoretical findings.

SIMULATION

This section uses the coefficients of the empirical estimation to simulate the effect of trade openness on the skill premium. The coefficients used depend on the level of

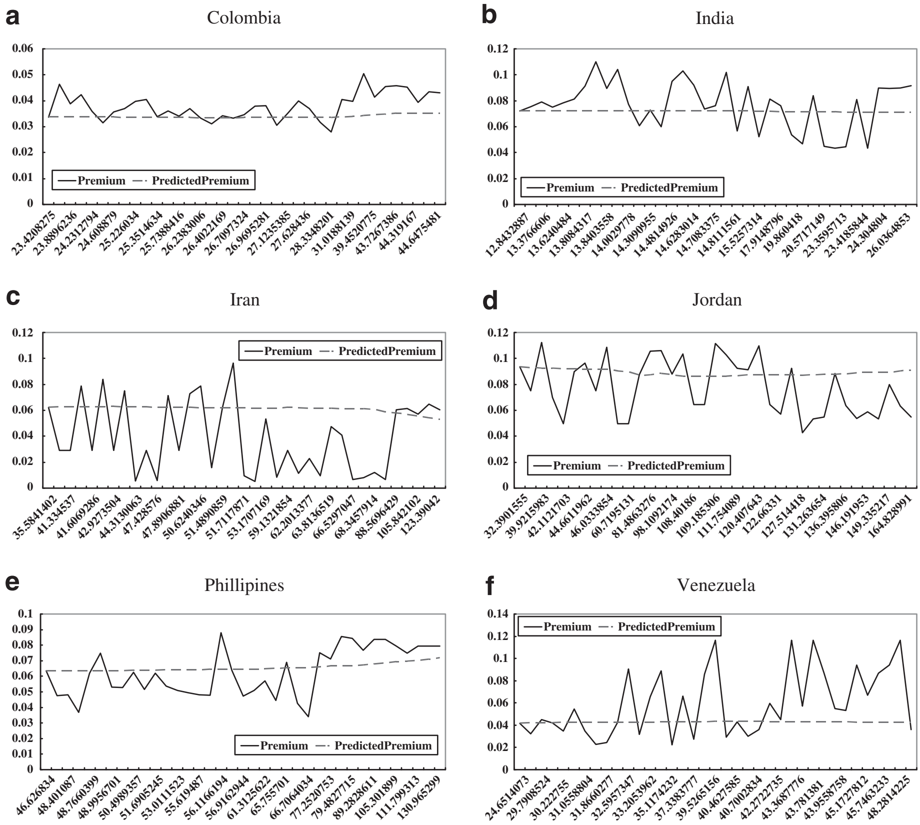

Figure 6. Openness, the skill premium, and the predicted skill premium.

skill abundance as shown in the threshold estimation. Given the skill abundance in every country, the coefficients of the threshold estimation are used to simulate the impact of trade openness on the skill premium. The predicted skill premium is compared with the actual skill premium observed in the data. This comparison is conducted in order to examine the success of the model and the estimation in explaining the patterns observed in the real world. The actual and the predicted skill premia in selected countries are displayed in Figures 6 and 7. The figures, for most of the countries, show that the predicted and the actual skill premium show similar patterns. This indicates that the predicted skill premium is successful in explaining most of the pattern of skill premia that we observe in the data.

CONCLUSION

The $2 \times 2 \times 2$ Heckscher–Ohlin model predicts that trade openness induces countries to export the good that intensively uses the relatively abundant factor of production and to import the good that intensively uses the relatively scarce factor of production. Accordingly, skill-abundant developed countries are expected to export the good that intensively uses skilled workers. This leads to an increase in the relative price of the skilled-intensive good, a rise in the relative demand for skilled workers, and consequently an increase in the skill premium. On the other hand,

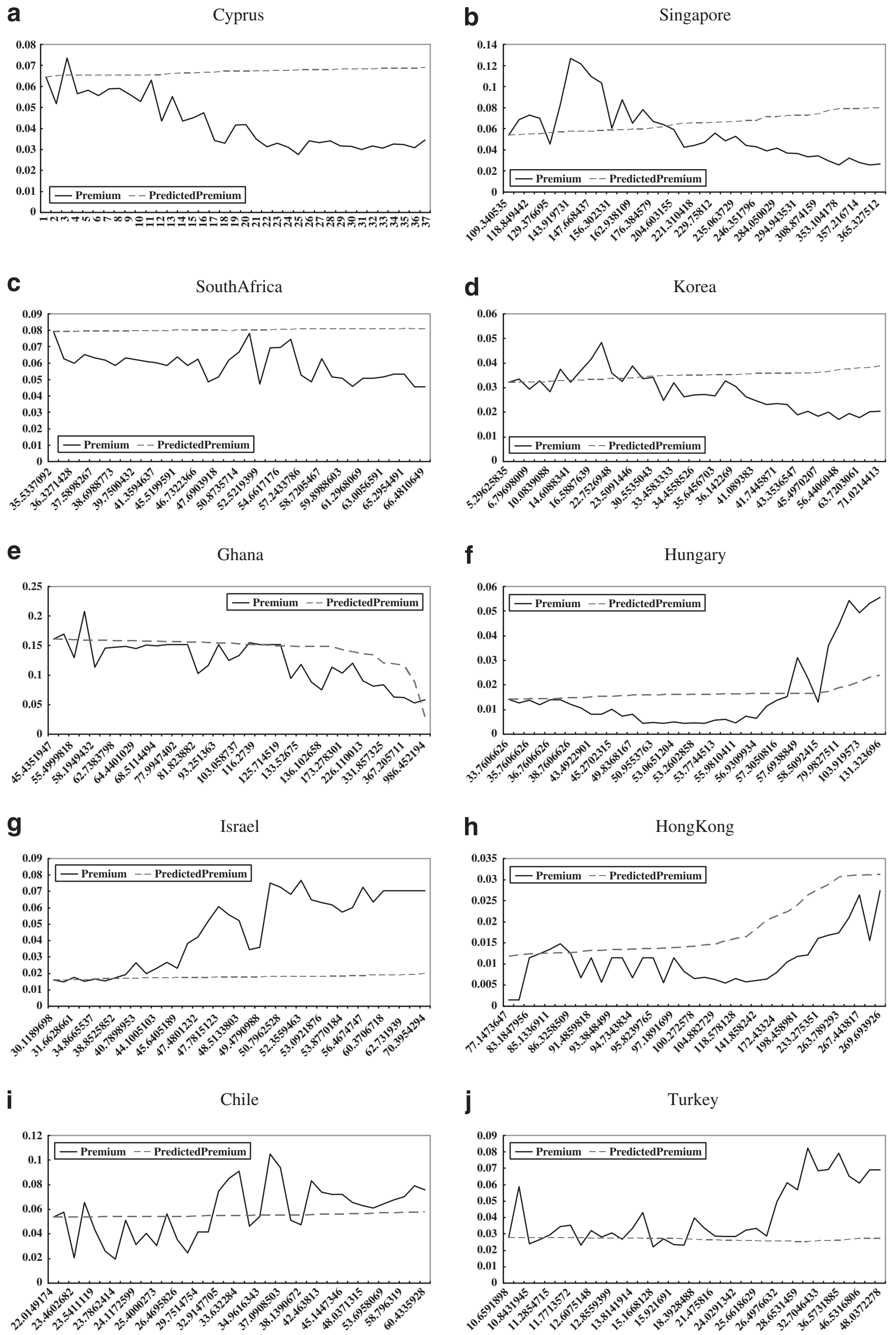

Figure 7. Openness, the skill premium, and the predicted skill premium.

skill-scarce developing countries are expected to export the good that intensively uses unskilled workers. This leads to an increase in the relative price of the unskilled-intensive good, a rise in the relative demand for unskilled workers, and consequently a decrease in the skill premium. Empirical evidence, however, demonstrates that although some developing countries witnessed a declining skill premium after trade liberalization, others experienced a widening wage gap after trade liberalization.

This paper attempts to address the inconsistency between the theoretical predictions and the observations. In this context, the paper introduces a two-country setup: the North and the South. In each country, the labor force is divided into skilled workers and unskilled workers. There are two types of final goods: a complex good and a simple good. The former is produced utilizing skilled workers. The latter is produced utilizing skilled workers and unskilled workers. Labor markets in the two countries feature search frictions. The skill premium is the ratio of the average wage of all skilled workers in both occupations to the wage of unskilled workers. Trade liberalization increases the skill premium in the North. In the South, the impact of trade liberalization on the skill premium depends on skill abundance. Developing countries that are more skill abundant experience an increase in the skill premium after trade liberalization, while others that are less skill abundant experience a decline in wage inequality. This can be intuitively explained as the higher the skill abundance in a developing country, the higher the average productivity of skilled workers compared with unskilled workers. This higher skill bias leads to a higher level of employment of skilled workers in simple occupations, since they are more productive relative to unskilled workers. This means that the increase in the price of the simple good, due to trade liberalization, will have a positive impact on the skill premium through the increase in the wage of the skilled workers in simple occupations. If their proportion is high, the increase in the price of the simple good leads to an increase in their total wage. This will offset any negative impact on the skill premium caused by the decrease in the wage of the skilled workers in complex occupations or the increase in the wage of the unskilled workers in simple occupations. The opposite impact on the skill premium takes place in countries that are less skill abundant in the South. Accordingly, the response of the skill premium to trade openness in developing countries is conditional upon skill abundance. An empirical analysis is implemented using the threshold estimation technique introduced by Hansen [1999]. The results suggest the presence of a statistically significant skill abundance threshold, below which the point estimate of the coefficient of the relationship between openness and wage inequality is negative, and above which the point estimate is positive.

Acknowledgements

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Appendix

Data

The estimation uses a balanced panel of annual data that covers the period from 1963 to 1999 for 50 developing and developed countries. The developed countries in the sample include: Australia, Austria, Canada, Denmark, Finland, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, the United Kingdom, and the United States. The developing countries in the sample include: Algeria, Chile, Colombia, Cyprus, Ecuador, El Salvador, Ghana, Honduras, Hong Kong, Hungary, India, Indonesia, Iran, Israel, Jamaica, Jordan, Kenya, Korea, Malawi, Malaysia, Mauritius, Mexico, Pakistan, Panama, Philippines, Singapore, South Africa, Syria, Taiwan, Tunisia, Turkey, Venezuela, and Zimbabwe. The variables used in the estimation are described in details as follows:

Skill premium
The skill premium or wage inequality data set is compiled by the University of Texas Inequality Project. The original data comes from the United Nations Industrial Development Organization statistics, which provide average manufacturing pay by industry. From these average industrial wages, a Theil index of inequality is calculated and used in this analysis as a measure of wage inequality. Detailed definition of this variable is included in Galbraith and Kum [2004].

Trade openness
Trade openness data is extracted from the Penn World Tables 6.2. Exports plus imports divided by real GDP is the total trade as a percentage of GDP. This is the constant price equivalent of the total trade as a percentage of GDP.

Skill abundance
Information on the relative supply of skilled and unskilled workers is available for only a few countries, while data on educational attainment is widely available and relatively comparable across countries. Therefore, as a proxy for the relative supply of skilled labor, we use average years of total education in the population aged over 15 years, as reported in Barro and Lee International Data on Educational Attainment. As the data is available only for the years 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, and 2000, we use linear interpolation to derive the years in between.

Real GDP per capita
The data for real GDP per capita (Laspeyres) is extracted from the Penn World Tables 6.2, which is obtained by adding up consumption, investment, government, and exports, and subtracting imports in any given year. The given year components are obtained by extrapolating the 1996 values in international dollars from the Geary aggregation using national growth rates.

Derivations

Wage of skilled workers in complex occupations
The wage of skilled workers in complex occupations is given by

$$W_i^{hc} = argmax\left[\Omega_i^{Ehc} - \Omega_i^{Dhc}\right]^{\xi_i}\left[\Omega_i^{Fhc}\right]^{1-\xi_i}$$

Wages can be derived from

$$(1-\xi_i)\left[\Omega_i^{Ehc} - \Omega_i^{Dhc}\right] = \xi_i\left[\Omega_i^{Fhc}\right]$$

Substituting $\Omega_i^{Ehc} = \left(\frac{W_i^{hc}+\chi_i^c\Omega_i^{Uh}}{r+\chi_i^c}\right)$, $\Omega_i^{Fhc} = \left(\frac{P_i^c\frac{\partial Y_i^c}{\partial N_i^{hc}} - W_i^{hc} + \chi_i^c\Omega_i^{Vc}}{r+\chi_i^c}\right)$, and $\Omega_i^{Dhc} = \left(\frac{b_i+\chi_i^c\Omega_i^{Uh}}{r+\chi_i^c}\right)$, we have

$$(1-\xi_i)\left[\frac{W_i^{hc}+\chi_i^c\Omega_i^{Uh}}{r+\chi_i^c} - \frac{b_i+\chi_i^c\Omega_i^{Uh}}{r+\chi_i^c}\right] = \xi_i\left[\frac{P_i^c\frac{\partial Y_i^c}{\partial N_i^{hc}} - W_i^{hc} + \chi_i^c\Omega_i^{Vc}}{r+\chi_i^c}\right]$$

Solving for W_i^{hc} yields (25).

Wage of skilled workers in simple occupations
The wage of skilled workers in simple occupations is given by

$$W_i^{hs} = argmax\left[\Omega_i^{Ehs} - \Omega_i^{Dhs}\right]^{\xi_i}\left[\Omega_i^{Fhs}\right]^{1-\xi_i}$$

Wages can be derived from

$$(1-\xi_i)\left[\Omega_i^{Ehs} - \Omega_i^{Dhs}\right] = \xi_i\left[\Omega_i^{Fhs}\right]$$

Substituting $\Omega_i^{Ehs} = \left(\frac{W_i^{hs}+\rho_i^c\Omega_i^{Ehc}+\chi_i^c\Omega_i^{Uh}}{r+\rho_i^c+\chi_i^c}\right)$, $\Omega_i^{Fhs} = \left(\frac{P_i^s\frac{\partial Y_i^s}{\partial N_i^{hs}} - W_i^{hs} + \left(\chi_i^c+\rho_i^c\right)\Omega_i^{Vs}}{r+\chi_i^c+\rho_i^c}\right)$, and $\Omega_i^{Dhs} = \left(\frac{b_i+\rho_i^c\Omega_i^{Ehc}+\chi_i^s\Omega_i^{Uh}}{r+\rho_i^c+\chi_i^s}\right)$, we have

$$(1-\xi_i)\left[\frac{W_i^{hs}+\rho_i^c\Omega_i^{Ehc}+\chi_i^c\Omega_i^{Uh}}{r+\rho_i^c+\chi_i^c} - \frac{b_i+\rho_i^c\Omega_i^{Ehc}+\chi_i^s\Omega_i^{Uh}}{r+\rho_i^c+\chi_i^s}\right]$$
$$= \xi_i\left[\frac{P_i^s\frac{\partial Y_i^s}{\partial N_i^{hs}} - W_i^{hs} + \left(\chi_i^c+\rho_i^c\right)\Omega_i^{Vs}}{r+\chi_i^c+\rho_i^c}\right]$$

Solving for W_i^{hs} yields (26).

Wage of unskilled workers in simple occupations
The wage of unskilled workers in simple occupations is given by

$$W_i^{ls} = argmax\left[\Omega_i^{Els} - \Omega_i^{Dls}\right]^{\xi_i}\left[\Omega_i^{Fls}\right]^{1-\xi_i}$$

Wages can be derived from

$$(1-\xi_i)\left[\Omega_i^{Els} - \Omega_i^{Dls}\right] = \xi_i\left[\Omega_i^{Fls}\right]$$

Substituting $\Omega_i^{Els} = \left(\frac{W_i^{ls}+\chi_i^s\Omega_i^{Ul}}{r+\chi_i^s}\right)$, $\Omega_i^{Fls} = \left(\frac{P_i^s\frac{\partial Y_i^s}{\partial N_i^{ls}} - W_i^{ls} + \chi_i^s\Omega_i^{Vs}}{r+\chi_i^s}\right)$, and $\Omega_i^{Dls} = \left(\frac{b_i+\chi_i^s\Omega_i^{Ul}}{r+\chi_i^s}\right)$, we have

$$(1-\xi_i)\left[\frac{W_i^{ls}+\chi_i^s\Omega_i^{Ul}}{r+\chi_i^s} - \frac{b_i+\chi_i^s\Omega_i^{Ul}}{r+\chi_i^s}\right] = \xi_i\left[\frac{P_i^s\frac{\partial Y_i^s}{\partial N_i^{ls}} - W_i^{ls} + \chi_i^s\Omega_i^{Vs}}{r+\chi_i^s}\right]$$

Solving for W_i^{ls} yields (27).

Proof of Proposition 1: The skill premium in the South, $i=S$, can be written as

$$\omega_i = \frac{N_i^{hc} W_i^{hc} + N_i^{hs} W_i^{hs}}{\left(N_i^{hc} + N_i^{hs}\right) W_i^{ls}} = \frac{N_i^{hc}\left[(1-\xi_i)b_i + \xi_i\left(P_i^c \frac{\partial Y_i^c}{\partial N_i^{hc}}\right)\right] + N_i^{hs}\left[(1-\xi_i)b_i + \xi_i\left(P_i^s \frac{\partial Y_i^s}{\partial N_i^{hs}}\right)\right]}{\left(N_i^{hc} + N_i^{hs}\right)\left[(1-\xi_i)b_i + \xi_i\left(P_i^s \frac{\partial Y_i^s}{\partial N_i^{ls}}\right)\right]}$$

As the South is assumed unskilled abundant compared with the North, the South exports the simple good after trade liberalization. This means that the price of the simple good P_S^s is expected to increase and the price of the complex good P_S^c is expected to decrease. The increase in the price of the simple good is expected to have a positive impact on the skill premium through the value of the marginal productivity of the skilled workers in simple occupations. This is also expected to have a negative impact on the skill premium through the value of the marginal productivity of the unskilled workers in simple occupations. The decrease in the price of the complex good is also expected to have a negative impact on the skill premium through the value of the marginal productivity of the skilled workers in complex occupations. The final effect on the skill premium depends on the relative magnitude of these effects. Therefore, the impact of a change in the price of the complex good on the skill premium is given by

$$\frac{\partial \omega_i}{\partial P_i^c} = \frac{N_i^{hc}\xi_i\left(\frac{\partial Y_i^c}{\partial N_i^{hc}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)}$$

The impact of a change in the price of the simple good on the skill premium is given by

$$\frac{\partial \omega_i}{\partial P_i^s} = \frac{N_i^{hs}\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{hs}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)} - \frac{\left[N_i^{hc}W_i^{hc} + N_i^{hs}W_i^{hs}\right]\left(N_i^{hc} + N_i^{hs}\right)\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{ls}}\right)}{\left[W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)\right]^2}$$

The impact of trade openness on the skill premium is positive in the South if and only if

$$\frac{N_i^{hs}\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{hs}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)} - \frac{\left[N_i^{hc}W_i^{hc} + N_i^{hs}W_i^{hs}\right]\left(N_i^{hc} + N_i^{hs}\right)\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{ls}}\right)}{\left[W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)\right]^2} + \frac{N_i^{hc}\xi_i\left(\frac{\partial Y_i^c}{\partial N_i^{hc}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)} > 0$$

This can be rewritten as

$$\frac{N_i^{hs}\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{hs}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)} > \frac{\left[N_i^{hc}W_i^{hc} + N_i^{hs}W_i^{hs}\right]\left(N_i^{hc} + N_i^{hs}\right)\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{ls}}\right)}{\left[W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)\right]^2} - \frac{N_i^{hc}\xi_i\left(\frac{\partial Y_i^c}{\partial N_i^{hc}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)}$$

Simplifying yields

$$\frac{N_i^{hs}\left(\frac{\partial Y_i^s}{\partial N_i^{hs}}\right)}{\left(N_i^{hc}+N_i^{hs}\right)\left(\frac{\partial Y_i^s}{\partial N_i^{ls}}\right)}+\frac{N_i^{hc}\left(\frac{\partial Y_i^c}{\partial N_i^{hc}}\right)}{\left(N_i^{hc}+N_i^{hs}\right)\left(\frac{\partial Y_i^s}{\partial N_i^{ls}}\right)}>\omega_i$$

Substituting the marginal productivities and simplifying yields

$$\left(\frac{N_i^{hc}}{N_i^{hc}+N_i^{hs}}\right)\left(\frac{A_i^c}{A_i^s}\right)\left(\frac{A_i^h}{A_i^l}\right)\left(\frac{A_i^hN_i^{hc}}{A_i^lN_i^{ls}+A_i^hN_i^{hs}}\right)^{\beta-1}>\omega_i-\left(\frac{N_i^{hs}}{N_i^{hc}+N_i^{hs}}\right)\left(\frac{A_i^h}{A_i^l}\right)$$

Simplifying further yields

$$\left(\frac{A_i^c}{A_i^s}\right)>\left(\frac{A_i^hN_i^{hc}}{A_i^lN_i^{ls}+A_i^hN_i^{hs}}\right)^{1-\beta}\left[\omega_i\left(\frac{N_i^{hc}+N_i^{hs}}{N_i^{hc}}\right)\left(\frac{A_i^l}{A_i^h}\right)-\left(\frac{N_i^{hs}}{N_i^{hc}}\right)\right]$$

The left-hand side of this inequality is independent of (A_i^h/A_i^l). On the other hand, the right-hand side declines in (A_i^h/A_i^l), since the first term is increasing in (A_i^h/A_i^l), while the second term is decreasing in (A_i^h/A_i^l). Therefore, there exists a threshold level of skill bias $(A_i^h/A_i^l)^*$, such that this holds as an equality. For developing countries where the skill bias is below this threshold, the inequality is not satisfied and the skill premium decreases after trade liberalization. For those developing countries where the skill bias is above this threshold, the inequality is satisfied and the skill premium increases after trade liberalization.

Proof of Proposition 2: The relative productivity is given by $\left((A_i^h/A_i^l)=(1/\widetilde{a})+1\right)$. Thus, $(\partial\widetilde{a}/\partial(H_i/L_i))<0$, because the smaller is the $\tilde{a}$, the larger is the portion of workers who choose to acquire skills. Therefore,

$$\frac{\partial\left(\frac{A_i^h}{A_i^l}\right)}{\partial\left(\frac{H_i}{L_i}\right)}=\left[\frac{\partial\left(\frac{A_i^h}{A_i^l}\right)}{\partial\tilde{a}}\right]\left[\frac{\partial\tilde{a}}{\partial\left(\frac{H_i}{L_i}\right)}\right]>0$$

Proof of Proposition 3: As the North is assumed more skilled-abundant compared with the South, the North exports the complex good after trade liberalization. This means that the price of complex good P_N^c is expected to increase and the price of the simple good P_N^s is expected to decrease. The decrease in the price of the simple good is expected to have a positive impact on the skill premium through the value of the marginal productivity of the unskilled workers in simple occupations. This price increase is expected to have a negative impact on the skill premium through the value of the marginal productivity of the skilled workers in simple occupations. The increase in the price of the complex good is also expected to have a positive impact on the skill premium through the value of the marginal productivity of the skilled workers in complex occupations. The final effect on the skill premium depends on the relative magnitude of these effects. Therefore, the impact of trade openness on the skill premium is positive in the North, where $i = N$, if and only if

$$\frac{\left[N_i^{hc}W_i^{hc} + N_i^{hs}W_i^{hs}\right]\left(N_i^{hc} + N_i^{hs}\right)\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{ls}}\right)}{\left[W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)\right]^2} - \frac{N_i^{hs}\xi_i\left(\frac{\partial Y_i^s}{\partial N_i^{hs}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)} < \frac{N_i^{hc}\xi_i\left(\frac{\partial Y_i^c}{\partial N_i^{hc}}\right)}{W_i^{ls}\left(N_i^{hc} + N_i^{hs}\right)}$$

This leads to the same condition as in Proposition 1. In the context of the endogenous skill bias, we expect the life expectancy to be longer in the North. Accordingly, the lifetime earnings of a skilled worker is going to be higher. Therefore, we expect that skill abundance in the North to be higher than the highest possible skill abundance in the South. As the North has a higher skill bias than any possible level in the South, it is higher than the threshold identified in Proposition 1. Thus, the inequality is satisfied and the skill premium increases in the North after trade liberalization.

Proof of Proposition 4: Consider the condition that guarantees that the impact of trade openness on the skill premium is positive in the South in the proof of Proposition 1. With a higher (A_i^c/A_i^s), the equality between the left- and right-hand sides are maintained with a lower (A_i^h/A_i^l). Therefore, a higher sector bias corresponds to a lower threshold skill bias $(A_i^h/A_i^l)^*$.

Notes

1. Detailed data description is included in Appendix section 'Data'.
2. This section surveys few studies that provide evidence on the incidence of overeducation. A more comprehensive and detailed survey of the literature on overeducation is included in the working paper version.
3. Detailed derivations are included in Appendix section 'Wage of skilled workers in complex occupations'.
4. Detailed derivations are included in Appendix section 'Wage of skilled workers in simple occupations'.
5. Detailed derivations are included in Appendix section 'Wage of unskilled workers in simple occupations'.

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