JOURNAL OF ECONOMIC DEVELOPMENT 1
Volume 35, Number 3, September 2010

OFFSHORING AND WAGE INEQUALITY IN DEVELOPING COUNTRIES

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The Heckscher-Ohlin model predicts that trade openness causes the skill premium to increase in skill-abundant developed countries, and to decrease in skill-scarce developing countries. Empirical evidence, however, shows that the skill premium declined in some developing countries, while others experienced an increase in wage inequality. This paper develops a North-South model, where firms produce a low-skilled and a high-skilled intensive good. The production of a unit of either good involves a continuum of L-tasks and H-tasks. The L-tasks can be performed by low-skilled workers, and the H-tasks can be performed by high-skilled workers. The Northern firms can produce the task in their headquarters, or offshore the task to the South. The results of the model suggest there is a threshold skill abundance level in the South, above which countries experience an increase in the skill premium after an improvement in the offshoring technology, and below which countries experience a decrease in the skill premium. The same pattern occurs with an improvement in the offshoring technology of tasks in the high-skilled and the low-skilled intensive industries. If wages in local production catch up with wages in the offshoring sector, offshoring does not impact wage inequality at a certain level of skill abundance. A threshold estimation, on 29 developing countries over the period 1982-2000, shows that there is a statistically significant skill abundance threshold, below which the coefficient on the relationship between offshoring and wage inequality is negative, and above which there is no impact of offshoring on wage inequality. Similar results are reached if offshoring is replaced by variables that proxy for the offshoring technology.

Keywords: Task Trade, Skill Premium, Threshold Estimation
JEL classification: F16, J31, O34

* We thank an anonymous referee for invaluable comments. Remaining errors are our own.

1. INTRODUCTION

The significance of international offshoring and fragmentation of production has been growing around the world in recent years. Firms are subcontracting an ever-increasing proportion of their activities, such as the production of intermediate inputs, services, and most recently - specific tasks. The flourishing ease with which hundreds of diverse activities and tasks could be offshored to a distant location nowadays, has prompted amplifying research in domestic and international outsourcing issues. One important aspect of these new trends in globalization, is the impact on the skill premia in both the country-source of offshoring, and the country-host. Naturally, the major part of current research has been focused on the consequences of these outsourcing activities in various parts of the world, including developing countries endowed with predominantly cheap labor, upon the labor in developed countries. The patterns of skill premia in the diverse developing world have attracted relatively less attention. The purpose of this paper is to focus on the theoretical and empirical analysis of the patterns of wage inequality in developing countries.

In this context, the 2x2x2 Heckscher-Ohlin model predicts that trade openness induces countries to export the good that intensively uses the relatively abundant factor of production, and 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 high-skilled workers. This leads to an increase in the relative price of the high-skilled intensive good, a rise in the relative demand for high-skilled workers, and consequently an increase in the skill premium. On the other hand, skill-scarce developing countries are expected to export the good that intensively uses low-skilled workers. This leads to an increase in the relative price of the low-skilled intensive good, a rise in the relative demand for low-skilled workers, and consequently a decrease in the skill premium. Theoretical predictions, however, are not supported by the observed empirical evidence. Some developing countries experienced an increase in the skill premium, while others witnessed a decline after trade openness. Evidence as to the asymmetric patterns of skill premia in the developing countries is documented by Freeman and Oostendorp (2001), Hanson and Harrison (1995), Robbins (1996), Wood (1997), and Goldberg and Pavcnik (2004).

As this poses a challenge to trade theorists, some studies have attempted to address this puzzle in order to resolve the discrepancies between the predictions of the theory and the empirical evidence. The first stream attributes the increase in the skill premium in the South to outsourcing and technology transfer. For instance, Feenstra and Hanson (1996) argue that outsourcing shifts a portion of input production from the North to the South. This portion is the most skilled-intensive in the South, and the most unskilled-intensive in the North. Hence, outsourcing increases relative skill demand and wage inequality 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, where the production of unskilled-intensive goods is relocated to the South. The relocated goods are the most skilled-intensive by Southern standards. This Southern catching-up raises the relative demand for skilled workers and thus exacerbates wage inequality. Yeaple (2003) demonstrates that in skill-scarce labor host countries, the flows of foreign direct investment by U.S.-based multinational companies are concentrated in low-skilled industries, whereas in skill-abundant labor host countries, the flows of foreign direct investment are concentrated in high-skilled industries. In theory, this can cause the skill premium to decrease in the former and to increase in the latter.

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, which increases the demand for skilled workers in the North. This causes an increase in the North's skilled labor cost, which 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 wage inequality. In addition, Beaulieu *et al.* (2004) present a model in which a reduction of trade barriers within the high-tech sector can raise the demand for these products in both countries, increase the demand for skilled labor, and thus increase wage inequality.

Other studies argue that trade induces skill-biased technological change. Acemoglu (2002, 2003) shows that trade creates a tendency for the relative price of skill-intensive goods to increase in the North. This makes the technologies used in the production of these goods more profitable to develop and encourages skill-biased technological change, which contributes to the increase in wage inequality. Since the South imitates the Northern technologies that are becoming more skill-biased, it experiences an increase in the skill premium as well. Thoenig and Verdier (2000) argue that when globalization triggers an increased threat of technological leapfrogging, firms respond by biasing the direction of their innovations towards skill-intensive technologies. In a model where only the North innovates and the South imitates, openness causes defensive skill-biased technical change in the North, and technical upgrading in the production of the imitated goods in the South to more skill-intensive ones. This generates an increase in wage inequality in both the North and the South.

Nevertheless, as much as these studies provide insights on the factors generating an increase in the skill premium in both the North and the South, they do not address the asymmetry of the response of the skill premium to trade openness among developing countries. The purpose of this paper is to provide an alternative explanation for the asymmetric patterns of skill premia observed, using the theory of task trade. In this context, Grossman and Rossi-Hansberg (2007, 2008a, 2008b) argue that advances in communication and information technologies have enabled the break-up of the production process into tasks, where the performance of these tasks is spread across the world. Therefore, international trade is becoming less a matter of countries' specialization in particular industries, and more about their specialization in particular tasks.

This paper develops a model of trading tasks between two countries: the North and the South, as in Khalifa and Mengova (2010). The North is more skill-abundant compared to the South. Firms in both countries produce a low-skilled intensive good and a high-skilled intensive good. There are two factors of production: low-skilled workers and high-skilled workers. The production of a unit of either good involves a continuum of *L*-tasks and a continuum of *H*-tasks. The *L*-tasks can be performed by low-skilled workers only, and the *H*-tasks can be performed by high-skilled workers only. If a task is performed offshore, the firm bears an extra cost of coordinating production and communicating with distant workers. This cost varies by task, as some require face-to-face contact or interaction between workers, while others are easier to perform from a distance. In this context, there exists a threshold *L*-task and a threshold *H*-task in every industry, below which all tasks are offshored to the South, and above which all tasks are produced in the headquarters in the North. In the South, some of the high-skilled and low-skilled workers supply their labor to the firms that serve as an external provider of a task to the Northern firms. Accordingly, the wages of the high-skilled and the low-skilled workers are a weighted average of the higher wage of those working in the offshoring firms, and of the lower wage of those hired by local producers in the South.

The results suggest that there is a threshold skill abundance level in the South. Countries with skill abundance above this threshold, are relatively more endowed with high-skilled workers. The Northern firms offshore their *H*-tasks to these countries to benefit from the relatively lower labor cost. This means that a higher proportion of the high-skilled workers in the South will be earning the higher wage, and the increase in their proportion causes an increase in the weighted average wage of the high-skilled workers, and accordingly an increase in the skill premium. Countries with skill abundance below this threshold, are relatively more endowed with low-skilled workers. The Northern firms offshore their *L*-tasks to these countries to benefit from the relatively lower labor cost. Therefore, a higher proportion of the low-skilled workers in the South will be earning the higher wage, and the increase in their proportion causes an increase in the weighted average wage of the low-skilled workers, and accordingly a decrease in the skill premium.

Consequently, in the South, countries that are more (less) skill-abundant, will have a lower (higher) cost of offshoring services for skilled tasks. The North offshores the high-skilled tasks to countries that are relatively more abundant in high-skilled workers, and low-skilled tasks to countries that are relatively more abundant in low-skilled workers. As a result, countries that become the hosts of low-skilled tasks will have a decrease in the skill premium, while those that become the hosts of the high-skilled tasks will have an increase in their skill premium, after an improvement in the offshoring technology. This provides a possible explanation for the asymmetric patterns of skill premia in the South. Our results also suggest that the threshold skill abundance becomes lower with an improvement in the technology of offshoring all tasks in the low-skilled intensive industry, than with an improvement in the technology of offshoring all tasks in the high-skilled intensive industry. If the wages in local production catch up with wages in the offshoring sector, then any improvement in the technology of offshoring will not impact the skill premium at a certain level of skill abundance.

An empirical analysis is undertaken to test our theoretical results using the threshold estimation techniques introduced by Hansen (1999) on a sample of 29 developing countries over the period 1982-2000. The empirical results suggest the presence of a statistically significant skill abundance threshold, below which the coefficient estimate of the relationship between offshoring and wage inequality is negative, and above which there is no impact of offshoring on wage inequality. Similar results are reached if we replace the level of offshoring with variables that proxy for the offshoring technology. Our estimation also supports the hypothesis that the threshold estimate in the case of offshoring tasks in the high-skilled intensive industry is higher than that in the low-skilled intensive industries.

The remainder of the paper is organized as follows: section 2 presents the model, section 3 includes the empirical estimation, section 4 is the conclusion, section 5 includes the derivations and data appendices. References, tables and figures are included thereafter.

2. MODEL

Our model presents two countries: the North and the South. Firms in the two countries produce a low-skilled intensive good and a high-skilled intensive good using two factors of production: low-skilled workers and high-skilled workers. The North is more skill-abundant compared to the South, or $\left(\frac{H}{L}\right) > \left(\frac{H^*}{L^*}\right)$, where H is the supply of high-skilled workers in the North, while L is the supply of low-skilled workers in the North. Similarly, H^* is the supply of high-skilled workers in the South, while L^* is the supply of low-skilled workers in the South.

In the North, firms can produce two goods, X and Y, with constant returns to scale. The production of a unit of either good involves a continuum of L-tasks and a continuum of H-tasks. We normalize the measure of tasks in each industry to one. The L-tasks can be performed by low-skilled workers only, while the H-tasks can be performed by high-skilled workers only. In any industry, the task that can be performed by a given factor requires similar amounts of that factor when performed at home. Industries may differ in their factor intensities. If a production technology allows no substitution between factors or tasks, each task must be performed at a fixed intensity in order to produce a unit of output. In industry X, a firm needs a_{LX} units of the low-skilled workers to perform a typical L-task once, and a_{HX} units of the high-skilled workers to perform a typical H-task once. Since the measure of L-tasks and H-tasks is normalized to one, a_{LX} is the total amount of low-skilled workers and a_{HX} is the total amount of high-skilled workers, that would be needed to produce a unit of good X in the absence of any offshoring. In industry *Y*, a firm needs a_{LY} units of the low-skilled workers to perform a typical *L*-task once, and a_{HY} units of the high-skilled workers to perform a typical *H*-task once. Since the measure of *L*-tasks and *H*-tasks is normalized to one, a_{LY} is the total amount of low-skilled workers and a_{HY} is the total amount of high-skilled workers, that would be needed to produce a unit of good *Y* in the absence of any offshoring. We will assume that industry *X* is more skill-intensive compared to *Y*, which means $\frac{a_{HX}}{a_{LX}} > \frac{a_{HY}}{a_{LY}}$.

Firms can undertake these tasks in the North, or offshore them to be performed in the South. Since some tasks are more difficult to offshore than others, we recognize the differences in terms of input requirements. A firm producing good *j* that offshores the *f*-task *i* abroad requires $\beta_{fj} a_{fj} t_{fj}(i)$ units of labor in the South, $\forall fj \in (LX, HX, LY, HY)$. β_{fj} is a parameter that reflects the technology of offshoring. A decline in β_{fj} represents the ease to offshore a given task abroad, and is equivalent to a decrease in the cost of offshoring. $t_{fj}(i)$ reflects improvements in the technology of offshoring that differs across the *i* tasks. We assume that $t_{fj}(i)$ is continuously differentiable and that $\beta_{fj} t_{fj}(i) \geq 1$, $\forall fj$, and $t'_{fj}(i) \geq 0$.

Let *w* be the wage of low-skilled workers in the North, w^* be the wage of the low-skilled workers hired to perform offshored *L*-tasks in the South, and w^{**} be the wage of the remaining low-skilled workers engaged in local production in the South. Let *s* be the wage of high-skilled workers in the North, s^* be the wage of the high-skilled workers hired to perform offshored *H*-tasks in the South, and s^{**} be the wage of the remaining high-skilled workers engaged in local production in the South. We also assume that $w > \beta_{LX} t_{LX}(0) w^*$, $w > \beta_{LY} t_{LY}(0) w^*$, $s > \beta_{HX} t_{HX}(0) s^*$ and $s > \beta_{HY} t_{HY}(0) s^*$, such that it is profitable for the North to conduct some tasks in the South. Thus, the Northern firms offshore tasks in order to take advantage of the lower wages in the South. In each industry, the marginal task performed in the North is determined by the condition that the savings in the wage costs just balance the offshoring costs as follows

$$w = \beta_{LX} t_{LX}(I_{LX}) w^*, \tag{1}$$

$$w = \beta_{LY} t_{LY}(I_{LY}) w^*, \tag{2}$$

$$s = \beta_{HX} t_{HX}(I_{HX}) s^*, \tag{3}$$

$$s = \beta_{HY} t_{HY}(I_{HY}) s^*, \tag{4}$$

where I_{fj} is the threshold task, below which all *f*-tasks in the production of good *j* are offshored to the South, and above which all *f*-tasks are produced in the headquarters in the North, as shown in Figures 1 and 2.

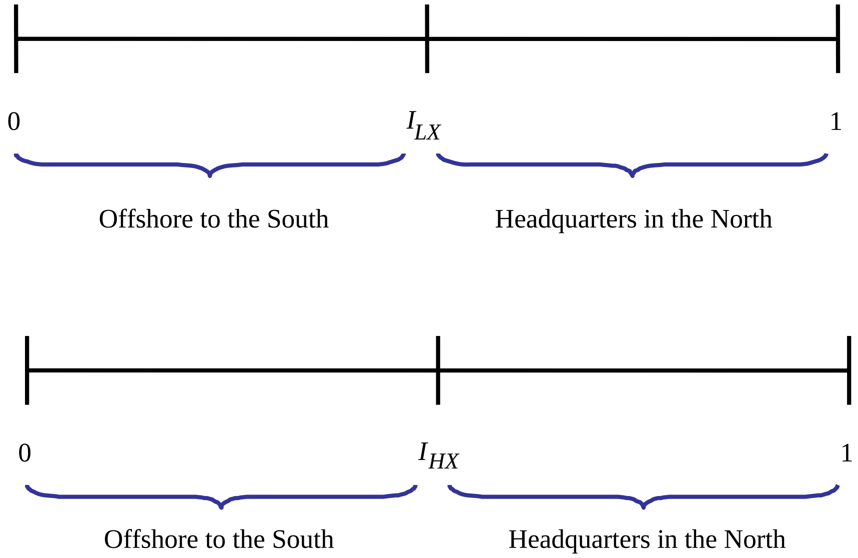

Figure 1. The Threshold *L*-task and *H*-task in the *X*-industry in the North

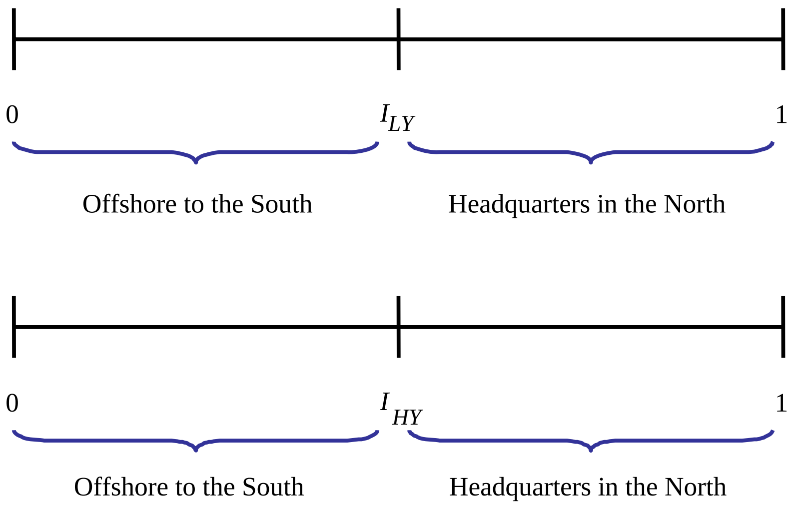

Figure 2. The Threshold *L*-task and *H*-task in the *Y*-industry in the North

In a competitive economy, the price of any good is less than or equal to the unit cost of production, with equality whenever a positive quantity of the good is produced. The unit cost of good *j* is the sum of the wages paid to the Northern low-skilled and high-skilled workers, and the wages paid to the Southern low-skilled and high-skilled workers. Accordingly, the price of good *X* is given by

$$P_X = wa_{LX}(1-I_{LX}) + w^* a_{LX} \int_0^{I_{LX}} \beta_{LX} t_{LX}(i)di + sa_{HX}(1-I_{HX}) + s^* a_{HX} \int_0^{I_{HX}} \beta_{HX} t_{HX}(i)di \,. \quad (5)$$

Similarly, the price of good *Y* is given by

$$P_Y = wa_{LY}(1-I_{LY}) + w^* a_{LY} \int_0^{I_{LY}} \beta_{LY} t_{LY}(i)di + sa_{HY}(1-I_{HY}) + s^* a_{HY} \int_0^{I_{HY}} \beta_{HY} t_{HY}(i)di \,, \quad (6)$$

where the first term in both equations is the labor cost of the low-skilled workers performing *L*-tasks in the headquarters in the North, the second term is the labor cost of the low-skilled workers performing offshored *L*-tasks in the South, the third term is the labor cost of the high-skilled workers performing H-tasks in the headquarters in the North, and finally the fourth term is the labor cost of the high-skilled workers performing offshored *H*-tasks in the South. Substituting (1) and (3) into (5) yields

$$P_X = wa_{LX}\Omega_{LX} + sa_{HX}\Omega_{HX} \,, \quad (7)$$

where $\Omega_{LX} = 1 - I_{LX} + \frac{\int_0^{I_{LX}} t_{LX}(i)di}{t_{LX}(I_{LX})}$, and $\Omega_{HX} = 1 - I_{HX} + \frac{\int_0^{I_{HX}} t_{HX}(i)di}{t_{HX}(I_{HX})}$.

Similarly, substituting (2) and (4) into (6) yields

$$P_Y = wa_{LY}\Omega_{LY} + sa_{HY}\Omega_{HY} \,, \quad (8)$$

where $\Omega_{LY} = 1 - I_{LY} + \frac{\int_0^{I_{LY}} t_{LY}(i)di}{t_{LY}(I_{LY})}$, and $\Omega_{HY} = 1 - I_{HY} + \frac{\int_0^{I_{HY}} t_{HY}(i)di}{t_{HY}(I_{HY})}$.

The assumption that $t'_{fj}(i) > 0$ for all $i \in [0,1]$ implies that $\Omega_{fj}(I_{fj}) < 1$ for $I_{fj} > 0$, which means that offshoring reduces the wage bill in proportion to the cost of performing the *f*-tasks at home, as long as some tasks are performed abroad. The improvement in the offshoring technology of the *f*-task in industry *i* is reflected in the decline of β_{fj}, or $\beta_{fj} < 0$.

Next, we consider the factor markets in the North. The markets for low-skilled and high-skilled labor clear when employment by the two industries in the tasks performed in the North exhausts the factor supply. The labor market clearing conditions in the North are given by

$$a_{LX}(1-I_{LX})X + a_{LY}(1-I_{LY})Y = L\,, \tag{9}$$

$$a_{HX}(1-I_{HX})X + a_{HY}(1-I_{HY})Y = H\ , \tag{10}$$

where X and Y denote the outputs of the two industries, respectively.

We assume that $w\beta_{LX}t_{LX}(0) > w^*$, $w\beta_{HX}t_{HX}(0) > w^*$, $s\beta_{LY}t_{LY}(0) > s^*$ and $s\beta_{HY}t_{HY}(0) > s^*$, which guarantee that the South does not offshore to the North, as it would be too expensive for the South to pay the Northern wages. Taking into consideration the offshoring decisions made by firms in the North, the number of the Southern low-skilled workers engaged in local production in the South, l^*, is given by

$$l^* = L^* - \left[\int_0^{I_{LX}} \beta_{LX} t_{LX}(i) a_{LX}\, di + \int_0^{I_{LY}} \beta_{LY} t_{LY}(i) a_{LY}\, di \right]. \tag{11}$$

Similarly, the number of the Southern high-skilled workers engaged in local production in the South, $\bar{h}^*$, is given by

$$\bar{h}^* = H^* - \left[\int_0^{I_{HX}} \beta_{HX} t_{HX}(i) a_{HX}\, di + \int_0^{I_{HY}} \beta_{HY} t_{HY}(i) a_{HY}\, di \right], \tag{12}$$

where $(L^* - l^*)$ is the number of Southern low-skilled workers performing the offshored L-tasks for Northern firms, and $(H^* - \bar{h}^*)$ is the number of Southern high-skilled workers performing the offshored H-tasks for Northern firms. Figures 3 and 4 show the division of low-skilled and high-skilled labor in the South between those engaged in local production in Southern firms, and those performing offshored tasks for Northern firms.

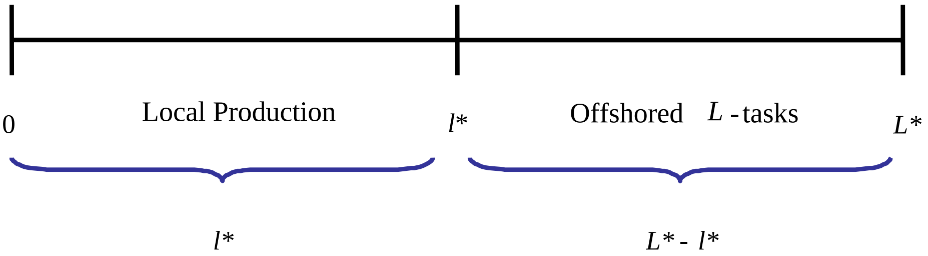

Figure 3. Division of Low-skilled Labor in the South between $\bar{l}^*$ Engaging in Local Production in the South, and $(L^* - \bar{l}^*)$ Performing Offshored *L*-tasks for Northern Firms

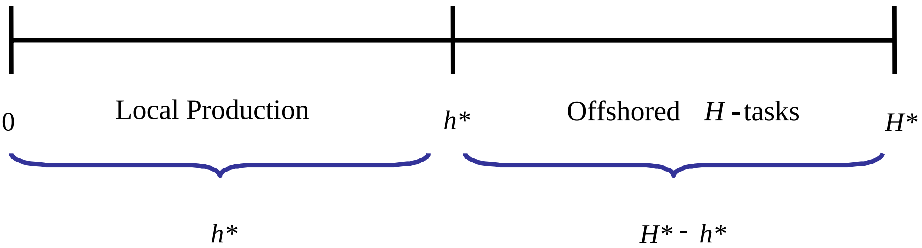

Figure 4. Division of High-skilled Labor in the South between $\bar{h}^*$ Engaging in Local Production in the South, and $(H^* - \bar{h}^*)$ Performing Offshored *H*-tasks for Northern Firms.

As in Grossman and Rossi-Hansberg (2008b), firms in the South must pay a small extra cost to acquire the capability to serve as an external provider of a task.[1] Assume

[1] The literature distinguishes between vertical integration and outsourcing. Vertical integration is a form of business organization in which all stages of production of a good, from the acquisition of raw materials to the retailing of the final product, are controlled by one company. According to Grossman and Rossi-Hansberg (2008b), they "*do not address the choice between vertical integration and outsourcing. Instead, we assume that firms use the same technology when performing tasks for themselves as when performing them for others. Moreover, firms must pay a small extra cost to acquire the capability to serve as an external provider of a task. In equilibrium, no firm has any incentive to pay this cost, so all tasks are performed in-house.*" Therefore, outsourcing can not occur in such an equilibrium. However, we assume that firms in the North are willing to cover this cost as long as their total cost of procuring the task from the South is less than their total cost of producing it in their headquarters in the North. This provides an incentive for firms in the South to perform offshoring services to Northern firms. If this payment is reflected in an increase in the wage of the workers who are producing these tasks in the South on behalf of the firms in the North, then we have an

the wage of the low-skilled workers hired to perform offshored *L*-tasks in these firms is w^*, while that of the remaining low-skilled workers engaged in local production in the South is w^{**}, where $w^* \geq w^{**}$,[2] then the weighted average wage of the low-skilled workers, w_L^S, is given by

$$w_L^S = \frac{l^* w^{**} + (L^* - l^*) w^*}{L^*} = \left(\frac{l^*}{L^*}\right) w^{**} + \left(1 - \frac{l^*}{L^*}\right) w^* . \tag{13}$$

Similarly, assume the wage of the the high-skilled workers hired to perform offshored *H*-tasks in these firms is s^*, while that of the remaining high-skilled workers engaged in local production is s^{**}, where $s^* \geq s^{**}$, then the weighted average wage of the high-skilled workers, w_H^S, is given by

$$w_H^S = \frac{\bar{h}^* s^{**} + (H^* - \bar{h}^*) s^*}{H^*} = \left(\frac{\bar{h}^*}{H^*}\right) s^{**} + \left(1 - \frac{\bar{h}^*}{H^*}\right) s^* . \tag{14}$$

In this context, the skill premium in the South is given by

$$w^S = \frac{w_H^S}{w_L^S} = \frac{\left(\frac{\bar{h}^*}{H^*}\right) s^{**} + \left(1 - \frac{\bar{h}^*}{H^*}\right) s^*}{\left(\frac{l^*}{L^*}\right) w^{**} + \left(1 - \frac{l^*}{L^*}\right) w^*} . \tag{15}$$

We will consider the case when $w^* > w^{**}$, and $s^* > s^{**}$, and then we will analyze the case when wages in local production catch up with wages in the offshoring sector, such that $w^* = w^{**}$, and $s^* = s^{**}$.

incentive for workers in the South to supply their labor to Southern firms providing offshoring services. Therefore, outsourcing can take place in equilibrium.

[2] Our assumption that the wages of workers in local production in the South are lower than the wages of workers in the offshoring sector is based on the findings in Sethupathy (2009) who shows that “following a new offshoring opportunity, offshoring firms increase their productivity and profitability at the expense of non-offshoring firms. This channel leads to higher domestic wages at offshoring firms and lower domestic wages at non-offshoring firms.” This assumption is also based on the evidence shown in Aitken *et al*. (1996) that Southern workers employed in multinational corporations earn higher wages on average compared to workers employed by domestic firms.

Proposition 1. *If* $w^* > w^{**}$, *and* $s^* > s^{**}$, $\exists$ *a threshold skill abundance in the South,* $\left(\frac{H^*}{L^*}\right)^T$, *below which an improvement in the technology of offshoring* $(d\beta < 0)$ *causes a decrease in the skill premium in the South, and above which the improvement in the technology of offshoring* $(d\beta < 0)$ *causes an increase in the skill premium in the South.*

Proof. Included in appendix 2.1■

This result provides a possible explanation for the asymmetric patterns of skill premia after trade openness among developing countries. The threshold skill abundance is displayed in figure 5. The intuition for the existence of this threshold is straightforward. Developed countries offshore their *H*-tasks to developing countries that are high-skilled abundant to benefit from the relatively lower labor cost. This means that more high-skilled workers in the South will be involved in performing offshored *H*-tasks for firms in the North. As their wage is higher than the wage of the remaining high-skilled workers in the South, the increase in the proportion of the high-skilled workers performing offshored tasks leads to an increase in their weighted average wage, and accordingly an increase in the skill premium. On the other hand, developed countries offshore their *L*-tasks to developing countries that are low-skilled abundant to benefit from the relatively lower labor cost. This means that more low-skilled workers in the South will be involved in performing offshored *L*-tasks for firms in the North. As their wage is higher than the wage of the remaining low-skilled workers in the South, the increase in the proportion of the low-skilled workers performing offshored tasks leads to an increase in their weighted average wage, and accordingly a decrease in the skill premium.

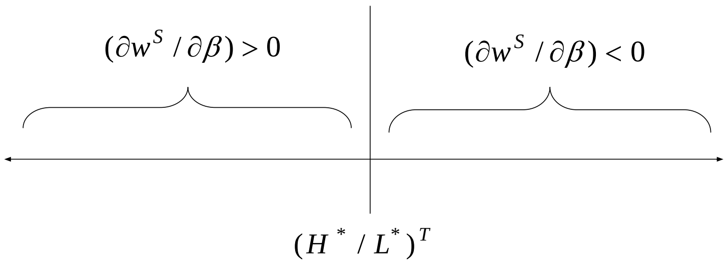

Figure 5. Threshold Skill Abundance in the South

Proposition 2. *If* $w^{*} = w^{**}$*, and* $s^{*} = s^{**}$*,* $\exists$ *a skill abundance level in the South,* $\left(\frac{H^{*}}{L^{*}}\right)^{TT} = \frac{(a_{HX} + a_{HY}) \int_{0}^{I_H} t_H(i)di}{(a_{LX} + a_{LY}) \int_{0}^{I_L} t_L(i)di}$*, below which an improvement in the technology of offshoring* $(d\beta < 0)$ *causes a decrease in the skill premium, while an improvement in the technology of offshoring* $(d\beta < 0)$ *does not affect the skill premium at this level of skill abundance,* $\left(\frac{\partial w^{S}}{\partial \beta} = 0\right)$.

Proof. Included in appendix 2.2■

In this case, when the wages in local production catch up with the wages in the offshoring sector, then any increase in offshoring activities due to an improvement in the technology of offshoring will not impact the skill premium at a certain level of skill abundance.

Proposition 3. *If* $w^{*} > w^{**}$*, and* $s^{*} > s^{**}$*, then: (1)* $\exists$ *a threshold skill abundance* $\left(\frac{H^{*}}{L^{*}}\right)^{TX}$*, below which the skill premium in the South decreases with an improvement in the technology of offshoring all tasks in the high-skilled intensive X-industry,* $(d\beta_X < 0)$*, and above which the skill premium increases in the South. (2)* $\exists$ *another threshold skill abundance* $\left(\frac{H^{*}}{L^{*}}\right)^{TY}$*, below which the skill premium in the South decreases with an improvement in the technology of offshoring all tasks in the low-skilled intensive Y-industry,* $(d\beta_Y < 0)$*, and above which the skill premium increases in the South. (3) We have* $\left(\frac{H^{*}}{L^{*}}\right)^{TX} > \left(\frac{H^{*}}{L^{*}}\right)^{TY}$.

Proof. Included in appendix 2.3■

This result is intuitive as well. An improvement in the offshoring technology of the high-skilled intensive *X*-industry, leads the North to offshore more *H*-tasks to produce good *X* to the developing countries that are relatively high-skilled abundant, and offshore more *L*-tasks to produce good *X* to the developing countries that are relatively low-skilled abundant. Therefore, the relative increase in the demand for high-skilled workers in the former will cause an increase in the skill premium, while the relative increase in the demand for low-skilled workers in the latter will cause a decrease in the skill premium. The same scenario takes place with an improvement in the offshoring technology of all tasks in the low-skilled intensive *Y*-industry. However, the threshold in the last case is smaller than in the first case. This is because the increase in the proportion of the high-skilled workers performing offshored tasks in the *Y*-industry relative to the increase in the proportion of the low-skilled workers performing offshored tasks in the *Y*-industry is smaller than that in the *X*-industry. This follows from the assumption that the *X*-industry is more skill intensive than the *Y*-industry, and that the relative labor requirement of high-skilled workers performing offshored *H*-tasks to that of the low-skilled workers performing offshored *L*-tasks in the *Y*-industry, $\int_0^{I_{HY}} t_{HY}(i)di \Big/ \int_0^{I_{LY}} t_{LY}(i)di$, is less than that in the *X*-industry, $\int_0^{I_{HX}} t_{HX}(i)di \Big/ \int_0^{I_{LX}} t_{LX}(i)di$. This means that developing countries whose skill abundance is lower than the threshold $\left(\frac{H^*}{L^*}\right)^{TX}$, will experience a decline in the skill premium after an improvement in the technology of offshoring all tasks in the *X*-industry, while those above the threshold $\left(\frac{H^*}{L^*}\right)^{TX}$ will experience an increase in the skill premium. Similarly, developing countries whose skill abundance is lower than the threshold $\left(\frac{H^*}{L^*}\right)^{TY}$, will experience a decrease in the skill premium after an improvement in the technology of offshoring all tasks in the *Y*-industry, while those above the threshold $\left(\frac{H^*}{L^*}\right)^{TY}$ will experience an increase in the skill premium. This also means that developing countries whose skill abundance is between $\left(\frac{H^*}{L^*}\right)^{TX}$ and $\left(\frac{H^*}{L^*}\right)^{TY}$ will experience a decrease in the skill premium after an improvement in the offshoring technology of all tasks in the *X*-industry, but will experience an increase in the skill premium after an improvement in the offshoring technology of all tasks in the *Y*-industry, as shown in figure 6. This is because the *Y*-industry has a lower relative high-skilled to low-skilled labor requirement for offshoring, as opposed to the *X*-industry. Therefore, countries with a relatively lower skill abundance can attract more *H*-tasks with an improvement in the offshoring of all tasks in the *Y*-industry than with an improvement in the offshoring of all tasks in the *X*-industry. This explains the smaller threshold in the case of an improvement in the technology of offshoring tasks in the low-skilled intensive industry compared to the case of an improvement in the technology of offshoring tasks in the high-skilled intensive industry.

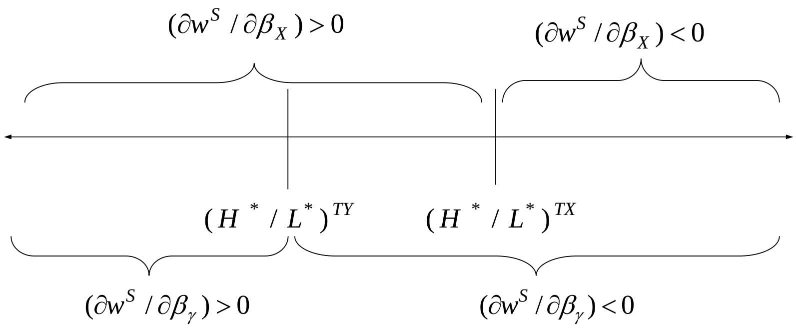

Figure 6. Threshold Skill Abundance in the South with an Improvement in the Technology of Offshoring Tasks in the *X*-industry and the *Y*-industry

Proposition 4. *If* $w^* = w^{**}$ *, and* $s^* = s^{**}$ *, then: (1)* $\exists$ *a level skill abundance in the South,* $\left(\frac{H^*}{L^*}\right)^{TTX} = \int_0^{I_{HX}} t_{HX}(i) a_{HX} di \Big/ \int_0^{I_{LX}} t_{LX}(i) a_{LX} di$ *, below which the skill premium in the South decreases with an improvement in the technology of offshoring all tasks in the high-skilled intensive X-industry,* $(d\beta_X < 0)$ *, while an improvement in the technology of offshoring these tasks* $(d\beta_X < 0)$ *does not affect the skill premium at this level of skill abundance. (2)* $\exists$ *a level skill abundance in the South,* $\left(\frac{H^*}{L^*}\right)^{TTY} = \int_0^{I_{HY}} t_{HY}(i) a_{HY} di \Big/ \int_0^{I_{LY}} t_{LY}(i) a_{LY} di$ *, below which the skill premium in the South decreases with an improvement in the technology of offshoring all tasks in the low-skilled intensive Y-industry,* $(d\beta_Y < 0)$ *, while an improvement in the technology of offshoring these tasks* $(d\beta_Y < 0)$ *does not affect the skill premium at this level of skill abundance. (3) We have* $\left(\frac{H^*}{L^*}\right)^{TTX} > \left(\frac{H^*}{L^*}\right)^{TTY}$ *.*

Proof. Included in appendix 2.4■

3. ESTIMATION

In this section, we test empirically the relationship between offshoring and wage inequality in developing countries using threshold estimation techniques developed in Hansen (1999). The threshold estimation model is given by

$$premium_{it} = \begin{cases} \mu_i + \beta_1 Offshoring_{it} + \phi_1 Openness_{it} + \phi_2 Abundance_{it} \\ + \phi_3 RGDP_{it} + e_{it}, \qquad\qquad if \;\; Abundance_{it} \le \sigma \\ \mu_i + \beta_2 Offshoring_{it} + \phi_1 Openness_{it} + \phi_2 Abundance_{it} \\ + \phi_3 RGDP_{it} + e_{it}, \qquad\qquad if \;\; Abundance_{it} > \sigma \end{cases}, \tag{16}$$

where the subscript *i* indexes the country, and the subscript *i* indexes time. The dependent variable $premium_{it}$ denotes the skill premium in country *i* in year *t*. The variable $Offshoring_{it}$ is a measure of offshoring, or U.S. foreign direct investment (FDI), in country *i* in year *t*. Offshoring is comprised of foreign direct investment and outsourcing. However, due to the lack of data on outsourcing (or the volume of subcontracted tasks), we focus our attention on FDI as a proxy for offshoring.[3] The variable $Openess_{it}$ 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 real gross domestic product per capita in country *i* in year *t*, and is added to control for macroeconomic developments which 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 model allows the level of skill abundance to determine the existence and significance of a threshold level in the relationship between offshoring and wage inequality rather than imposing a priori an arbitrary classification scheme. The

[3] Offshoring measures a production process, where at least some part of it is performed abroad. The part of the production process performed abroad, could be either the result of FDI, which is directly measurable in the U.S. accounts, and constitutes the biggest proportion of offshoring, or alternatively, could be the result of arms-length trade, where a U.S. firm signs a contract with a local producer to perform a specific job, or a task. The latter is very difficult to account for, or to measure directly, since it does not enter directly into the U.S. balance of payments, and it constitutes a relatively small portion of the total offshoring. Therefore, studies in this line of research have resorted to using empirical proxies for offshoring, usually taking FDI as the closest possible substitute. Following Grossman and Helpman (2002) and Trefler (2006), we define offshoring to include the movement of production processes abroad, but kept within the firm (vertical FDI) as well as arms-length transactions. Sethupathy (2009) uses the same empirical methodology on U.S. FDI data from the Bureau of Economic Analysis and Mexican data, and recognizes the same restrictions on data availability.

threshold skill abundance determines whether the coefficient on offshoring is positive or negative. 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 either positive as in proposition 1 or insignificant as in proposition 2. Another way of writing the equation of interest is

$$\begin{aligned} premium_{it} = {} & \mu_i + \beta_1 Offshoring_{it} I(Abundance_{it} \le \sigma) \\ & + \beta_2 Offshoring_{it} I(Abundance_{it} > \sigma) + \phi_1 Openness_{it} \\ & + \phi_2 Abundance_{it} + \phi_3 RGDP_{it} + e_{it}, \end{aligned} \tag{17}$$

where $I(.)$ is the indicator function. A balanced panel annual data is used for 29 developing countries over the period from 1982 to 2000. 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 data on educational attainment, is used as a measure of skill abundance. The United States direct investment abroad from the Bureau of Economic Analysis is used as a proxy for offshoring. 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.

Table 1. Summary Statistics (Offshoring Sample)

	Minimum	25% quantile	Median	75% quantile	Maximum
$Premium_{it}$	0.0025	0.0334	0.0570	0.0827	0.2752
$RGDP_{it}$	888.5339	3810.1869	6145.9131	9423.0404	29433.7712
$Abundance_{it}$	2.7632	4.8408	6.0474	7.4420	10.8370
$Openness_{it}$	10.0020	51.2325	50.6465	109.9234	44.7677
$Offshoring_{it}$	0.0000	488.0000	1466.0000	3451.0000	39352.0000
$High\ Skilled\ Offshoring_{it}$	0.0000	22.0000	191.0000	883.0000	24062.0000
$Low\ Skilled\ Offshoring_{it}$	0.0000	210.0000	798.0000	2015.0000	19274.0000

Table 2. Summary Statistics (Offshoring Technology Sample)

	Minimum	25% quantile	Median	75% quantile	Maximum
$Premium_{it}$	0.0041	0.0374	0.0653	0.0910	0.2625
$RGDP_{it}$	1896.8130	4079.4902	6768.5475	10573.1715	29433.7712
$Abundance_{it}$	3.1244	5.0864	6.3320	7.6402	10.8370
$Openness_{it}$	15.1931	43.3355	76.3931	34.1383	44.7677
$Cellular_{it}$	0.0000	0.2878	1.3707	4.9365	81.7906
$Internet_{it}$	0.0000	0.0295	0.2802	1.6952	40.5037

To determine the number of thresholds, the model is estimated by least squares allowing for zero, one, two, and three thresholds. In Table 3, the test for a single threshold is significant with a bootstrap[4] *p*-value of 0.0267. On the other hand, the test for a double threshold is not significant with a bootstrap *p*-value of 0.9267. Similarly, the test for a triple threshold is not significant, with a bootstrap *p*-value of 0.9767. Thus, we conclude that there is evidence of only one threshold in the regression relationship.

Table 3. Tests for Threshold Effects for All Industries (Offshoring)

	All Industries
Test for Single Threshold	
F_1	92.1580
p-value	0.0267
(10%, 5%, 1% critical values)	(63.5645, 76.7147, 126.6712)
Test for Double Threshold	
F_2	7.2780
p-value	0.9267
(10%, 5%, 1% critical values)	(61.4921, 77.1760, 111.6403)
Test for Triple Threshold	
F_3	4.4730
p-value	0.9767
(10%, 5%, 1% critical values)	(32.9101, 38.6363, 55.7092)

Table 4. Tests for Threshold Effects for All Industries (Offshoring Technology)

	Cellular	Internet
Test for Single Threshold		
F_1	78.7528	79.3166
p-value	0.0400	0.0033
(10%, 5%, 1% critical values)	(47.4166, 66.2353, 106.8829)	(35.0886, 40.2593, 71.2809)
Test for Double Threshold		
F_2	33.6341	166.2206
p-value	0.0200	0.0067
(10%, 5%, 1% critical values)	(23.1061, 27.7534, 37.8847)	(26.1759, 39.5219, 104.4489)
Test for Triple Threshold		
F_3	3.9316	6.5669
p-value	0.6700	0.1933
(10%, 5%, 1% critical values)	(13.3500, 17.0553, 21.8221)	(9.2070, 12.9432, 20.5888)

[4] 300 bootstrap replications are used for each of the three bootstrap tests.

The point estimate of the threshold is 2.9964, and its asymptotic 99% confidence interval is [2.9964, 3.0752]. More information can be learned from plots of the concentrated likelihood ratio function displayed in Figure 7. To examine the first-step likelihood ratio function which is computed when estimating a single threshold model, we see that the first-step threshold estimate is the point where the likelihood function equals zero, which occurs at $\sigma = 2.9964$.

Table 5. Tests for Threshold Effects for High-skilled and Low-skilled Industries

	High-Skilled Industries	Low-skilled Industries
Test for Single Threshold		
F_1	89.8852	89.3219
p-value	0.0333	0.0467
(10%, 5%, 1% critical values)	(72.2670, 81.6811, 117.6502)	(67.7671, 86.8367, 137.3502)
Test for Double Threshold		
F_2	29.9838	7.8094
p-value	0.4133	0.9033
(10%, 5%, 1% critical values)	(62.9321, 76.7009, 114.9622)	(61.1903, 77.1844, 95.8895)
Test for Triple Threshold		
F_3	5.4520	5.1810
p-value	0.8733	0.9500
(10%, 5%, 1% critical values)	(23.8600, 32.0297, 40.9005)	(28.8201, 33.9639, 51.8149)

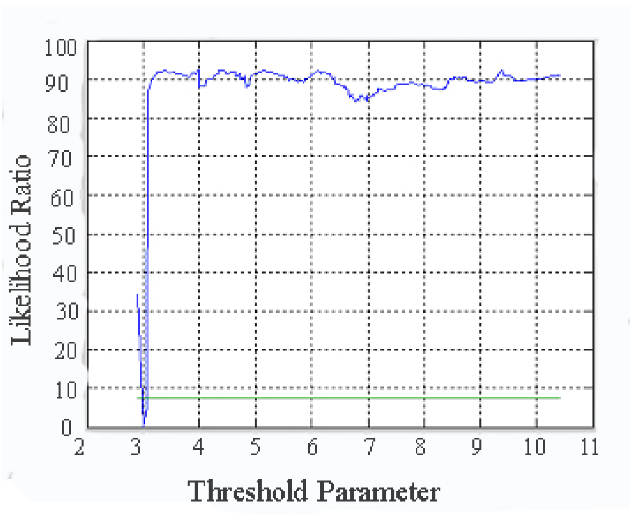

Figure 7. Confidence Interval Construction in the Single Threshold Model for All Industries

The regression slope estimates, conventional OLS standard errors, and white-correlated standard errors are reported in Table 6. Real GDP per capita does not have any effect on wage inequality. Skill abundance has a significant positive impact on wage inequality with a coefficient of 0.0191. Trade openness also has a significantly positive coefficient with wage inequality as expected. The estimates of primary interest are those on offshoring. Offshoring has a significant negative effect on wage inequality with a coefficient of -0.0005, if skill abundance is below the first threshold 2.9964. On the other hand, offshoring has no impact on wage inequality if skill abundance is above the threshold.

Table 6. Regression Estimates for All Industries

Regressor	Coefficient Estimate	OLS SE	White SE
$RGDP_{it}$	-0.000003***	0.000001	0.000001
$Abundance_{it}$	0.01914***	0.00279	0.00209
$Openness_{it}$	0.00010**	0.00007	0.00007
$Offshoring_{it} I$ $Abundance_{it} \leq 2.9964$	-0.00052***	0.00006	0.00010
$Offshoring_{it} I$ $Abundance_{it} > 2.9964$	-0.00000	0.00000	0.00000
Observations=493	Sum of Squared Errors=0.2223		

Note: *** indicates significance at 1%, ** at 5%, * at 10%.

Instead of the level of offshoring, we use variables to proxy for the offshoring technology. Improvements in communication technology are changing the rules on what can be produced domestically versus abroad. Therefore, we use variables such as the number of internet users per 100 people, and the mobile cellular phone subscriptions per 100 people, as proxies for improvements in offshoring technology. Offshoring is facilitated by the availability of cellular phones and wider access to the internet. In this case, the equation to estimate is

$$\begin{aligned} premium_{it} = \mu_i &+ \beta_1 OffshoringTechno\log y_{it} I(Abundance_{it} \leq \sigma) \\ &+ \beta_2 OffshoringTechno\log y_{it} I(Abundance > \sigma) + \phi_1 Openness_{it} \\ &+ \phi_2 Abundance_{it} + \phi_3 RGDP_{it} + e_{it}, \end{aligned} \tag{18}$$

where $OffshoringTechnology_{it}$ can be either the number of cellular phone subscribers or internet users, per 100 people, in country i in year t. The same sample of countries that is used in the previous analysis is utilized in this context, with the exception of Taiwan, over a shorter period from 1992 to 2000. Data description is included in the appendix. Summary statistics of the variables used in this estimation are provided in Table 2. Table

4 shows the significance of two thresholds, whether we are using the cellular phone, or internet use, as a proxy for offshoring technology. Table 7 shows that cellular phone subscriptions have a significantly negative effect on the skill premium for countries with a level of skill abundance below the second threshold 3.4406, while the coefficient is insignificant above this threshold. Table 8 shows that internet use has a significantly negative effect on the skill premium for countries with a level of skill abundance below the second threshold 4.5230, while the coefficient is insignificant above this threshold. These results suggest that using variables that proxy for offshoring technology, instead of the level of offshoring, also support the findings in proposition 2.

Table 7. Regression Estimates for All Industries

Regressor	Coefficient Estimate	OLS SE	White SE
$RGDP_{it}$	0.000001	0.000002	0.000002
$Abundance_{it}$	0.00297	0.00811	0.00798
$Openness_{it}$	-0.00003	0.00013	0.00009
$Cellular_{it}I$ $Abundance_{it} < 3.2984$	0.30248***	0.05648	0.12435
$Cellular_{it}I$ $3.2984 \leq Abundance_{it} < 3.4406$	-0.08064***	0.01529	0.04923
$Cellular_{it}I$ $Abundance_{it} > 3.4406$	-0.00004	0.00016	0.00008
Observations=196	Sum of Squared Errors=0.0307		

Note: *** indicates significance at 1%, ** at 5%, * at 10%.

Table 8. Regression Estimates for All Industries

Regressor	Coefficient Estimate	OLS SE	White SE
$RGDP_{it}$	0.000001	0.000002	0.000002
$Abundance_{it}$	0.00773	0.00646	0.00709
$Openness_{it}$	0.00001	0.00010	0.00008
$Internet_{it}I$ $Abundance_{it} < 3.3932$	-1.74133***	0.13357	0.16208
$Internet_{it}I$ $3.3932 \leq Abundance_{it} < 4.5230$	-0.23135***	0.01754	0.03830
$Internet_{it}I$ $Abundance_{it} > 4.5230$	-0.00003	0.00029	0.00013
Observations=196	Sum of Squared Errors=0.0194		

Note: *** indicates significance at 1%, ** at 5%, * at 10%.

Table 9. Regression Estimates for High-skilled Industries

Regressor	Coefficient Estimate	OLS SE	White SE
$RGDP_{it}$	-0.000004***	0.000001	0.000001
$Abundance_{it}$	0.01815***	0.00265	0.00193
$Openness_{it}$	0.00008	0.00008	0.00007
$Offshoring_{it} I$ $Abundance_{it} \leq 3.0752$	-0.00500***	0.00055	0.00107
$Offshoring_{it} I$ $Abundance_{it} > 3.0752$	0.000000	0.000001	0.000000
Observations=493	Sum of Squared Errors=0.2237		

Note: *** indicates significance at 1%, ** at 5%, * at 10%.

Table 10. Regression Estimates for Low-skilled Industries

Regressor	Coefficient Estimate	OLS SE	White SE
$RGDP_{it}$	-0.000003***	0.000001	0.000001
$Abundance_{it}$	0.01947***	0.00271	0.00198
$Openness_{it}$	0.00010*	0.00007	0.00006
$Offshoring_{it} I$ $Abundance_{it} \leq 2.9964$	-0.00059***	0.00007	0.00011
$Offshoring_{it} I$ $Abundance_{it} > 2.9964$	-0.000001	0.000001	0.000000
Observations=493	Sum of Squared Errors=0.2228		

Note: *** indicates significance at 1%, ** at 5%, * at 10%.

Finally, we divide industries into high-skilled and low-skilled, in order to test empirically propositions 3 and 4. The classification of industries into high-skilled and low-skilled is provided in the data appendix, and in Tables 11 and 12. The threshold estimation model for the offshoring of high-skilled industries is given by

$$\begin{aligned} premium_{it} &= \mu_i + \beta_1 HighSkilled\,Offshoring_{it} I(Abundance_{it} \leq \sigma^H) \\ &+ \beta_2 HighSkilled\,Offshoring_{it} I(Abundance > \sigma^H) + \phi_1 Openness_{it} \\ &+ \phi_2 Abundance_{it} + \phi_3 RGDP_{it} + e_{it}, \end{aligned} \tag{19}$$

where the the variable $HighSkilled\,Offshoring_{it}$ is a measure the U.S. foreign direct investment in the high-skilled industries in country *i* in year *t*. In Table 5, the test for a single threshold is significant with a bootstrap[5] *p*-value of 0.0333. On the other hand, the test for a double threshold is not significant with a bootstrap *p*-value of 0.4133. Similarly, the test for a triple threshold is not significant, with a bootstrap *p*-value of 0.8733. Thus, we conclude that there is only one threshold in the regression relationship.

Table 11. High-skilled Industries Classification

1982-1998	1999-2000
Industrial Machinery and Equipment Electrical Equipment, Appliances and Components Transportation Equipment Finance, Insurance, Real Estate Services	Machinery Electrical Equipment, Appliances and Components Transportation Equipment Computer and Electronic Products Information Finance and Insurance Professional, Scientific and Technical Services

Table 12. Low-skilled Industries Classification

1982-1998	1999-2000
Petroleum Food and Kindred Products Chemical and Allied Products Primary and Fabricated Metals Other Manufacturing Wholesale Trade Depository Institutions Other Industries	Mining Food Chemicals Primary and Fabricated Metals Other Manufacturing Wholesale Trade Depository Institutions Other Industries Utilities Holding Companies

The point estimate of the threshold is 3.0752, and its asymptotic 99% confidence interval is [2.9964, 3.0752]. The concentrated likelihood ratio function is displayed in Figure 8. The regression slope estimates, conventional OLS standard errors, and white-correlated standard errors are reported in Table 9. Real GDP per capita does not have any effect on wage inequality. Skill abundance has a significant positive impact on wage inequality with a coefficient of 0.0181. Trade openness also has a significantly

[5] 300 bootstrap replications are used for each of the three bootstrap tests.

positive coefficient with wage inequality as expected. The estimates of primary interest are those on offshoring. Offshoring has a significant negative effect on wage inequality with a coefficient of -0.0050, if skill abundance is below the first threshold 3.0752. On the other hand, offshoring has no impact on wage inequality if skill abundance is above the threshold.

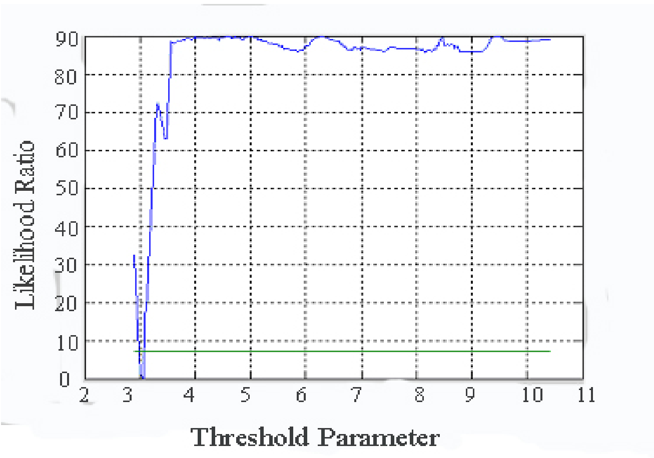

Figure 8. Confidence Interval Construction in the Single Threshold Model for High-skilled Industries

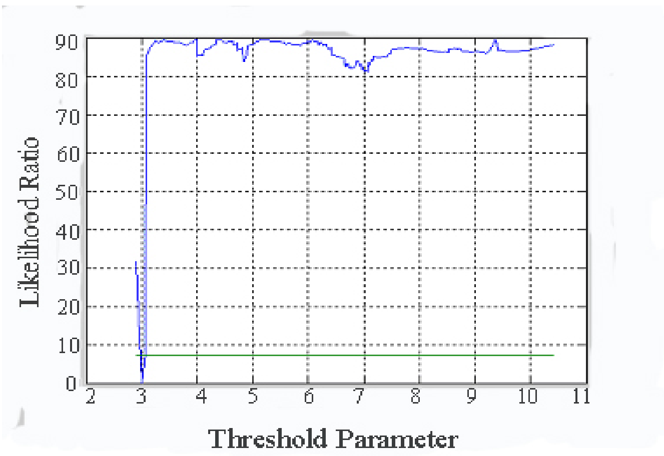

Figure 9. Confidence Interval Construction in the Single Threshold Model for Low-skilled Industries

Finally, the threshold estimation model for the offshoring of low-skilled industries is given by

$$\begin{aligned} premium_{it} &= \mu_i + \beta_1 LowSkilled\,Offshoring_{it} I(Abundance_{it} \le \sigma^L) \\ &+ \beta_2 LowSkilled\,Offshoring_{it} I(Abundance > \sigma^L) + \phi_1 Openness_{it} \\ &+ \phi_2 Abundance_{it} + \phi_3 RGDP_{it} + e_{it}, \end{aligned} \tag{20}$$

where the variable $LowSkilled\,Offshoring_{it}$ is a measure of U.S. foreign direct investment in the low-skilled industries in country *i* in year *t*. In Table 5, the test for a single threshold is significant with a bootstrap[6] *p*-value of 0.0467. On the other hand, the test for a double threshold is not significant with a bootstrap *p*-value of 0.9033. Similarly, the test for a triple threshold is not significant, with a bootstrap *p*-value of 0.9500. Thus, we conclude that there is one threshold in the regression relationship.

The point estimate of the threshold is 2.9964. The concentrated likelihood ratio function is displayed in Figure 9. The regression slope estimates, conventional OLS standard errors, and white-correlated standard errors are reported in Table 10. Real GDP does not have any effect on wage inequality. Skill abundance has a significant positive impact on wage inequality with a coefficient of 0.0195. Trade openness also has a significantly positive coefficient with wage inequality as expected. The estimates of primary interest are those on offshoring. Offshoring has a significant negative effect on wage inequality with a coefficient of -0.0006, if skill abundance is below the first threshold 2.9964. Offshoring has no impact on wage inequality if skill abundance is above the threshold.

4. CONCLUSION

The 2x2x2 Heckscher-Ohlin model predicts that trade openness induces countries to export the good that intensively uses the relatively abundant factor of production, and 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 high-skilled workers. This leads to an increase in the relative price of the high-skilled intensive good, a rise in the relative demand for high-skilled workers, and consequently an increase in the skill premium. On the other hand, skill scarce developing countries are expected to export the good that intensively uses low-skilled workers. This leads to an increase in the relative price of the low-skilled intensive good, a rise in the relative demand for low-skilled workers, and consequently a decrease in the skill premium. Empirical evidence in several studies, however, demonstrates that

[6] 300 bootstrap replications are used for each of the three bootstrap tests.

although some developing countries have witnessed a declining skill premium, others have experienced a widening wage gap after trade liberalization.

Our theoretical results show that there is a threshold skill abundance level in the South. Countries with skill abundance above this threshold, are relatively more endowed with high-skilled workers. The Northern firms offshore their *H*-tasks to these countries to benefit from the relatively lower labor cost. This means that a higher proportion of the high-skilled workers in the South will be earning the higher wage, and the increase in their proportion will cause an increase in the weighted average wage of the high-skilled workers, and accordingly an increase in the skill premium. Countries with skill abundance below this threshold, are relatively more endowed with low-skilled workers. The Northern firms offshore their *L*-tasks to these countries to benefit from the relatively lower labor cost. Therefore, a higher proportion of the low-skilled workers in the South will be earning the higher wage, and the increase in their proportion will cause an increase in the weighted average wage of the low-skilled workers, and accordingly a decrease in the skill premium.

Consequently, in the South, countries that are more (less) skill abundant, will have a lower (higher) cost of offshoring services for skilled tasks. The North offshores the high-skilled tasks to countries that are relatively more abundant in high-skilled workers, and low-skilled tasks to countries that are relatively more abundant in low-skilled workers. As a result, countries that become the hosts of low-skilled tasks will have a decrease in the skill premium, while those that become the hosts of the high-skilled tasks will have an increase in their skill premium, after an improvement in the offshoring technology. This provides a possible explanation to the asymmetric patterns of skill premia in the South. Our results also suggest that the threshold skill abundance becomes lower with an improvement in the technology of offshoring all tasks in the low-skilled intensive industry, than with an improvement in the technology of offshoring all tasks in the high-skilled intensive industry.

We test our findings empirically using the threshold estimation technique introduced by Hansen (1999) on a sample of 29 developing countries over the period 1982-2000. The results suggest the presence of a statistically significant skill abundance threshold, below which the coefficient estimate of the relationship between offshoring and wage inequality is negative, and above which there is no impact of offshoring on wage inequality. Similar results are reached if we replace the level of offshoring with variables that proxy for the offshoring technology. The estimation also supports the hypothesis that the threshold estimate in the case of offshoring tasks in the high-skilled intensive industry is higher than that in the low-skilled intensive industries.

Appendix

1. Data

The estimation uses a balanced panel of annual data that covers the period from 1982 to 2000 for 29 developing countries, namely: Argentina, Barbados, Chile, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Guatemala, Honduras, Hong Kong, India, Indonesia, Israel, Jamaica, Korea, Malaysia, Mexico, Panama, Peru, Philippines, Singapore, South Africa, Taiwan, Thailand, Trinidad and Tobago, Turkey, and Venezuela. The variables used in the estimation are described in detail as follows:

1.1. Skill Premium

The skill premium, or wage inequality, dataset used is compiled by the University of Texas Inequality Project. The original data comes from UNIDO 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).

1.2. Trade Openness

Trade openness data are extracted from the Penn World Tables 6.2. Exports plus Imports divided by real Gross Domestic Product 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.

1.3. 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. Some studies suggest combining the data on educational attainment with observations on skill abundance to posit a relationship between these two variables and interpolate the relative supply of skilled workers for other countries. However, as Forbes (2001) argued that “this procedure is imprecise since the interpolation uses three points to draw two lines, and even these three points are of dubious accuracy and comparability.” 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.

1.4. Real GDP per capita

The data for real Gross Domestic Product per capita (Laspeyres) are extracted from the Penn World Tables 6.2, which is obtained by adding up consumption, investment, government expenditures 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.

1.5. U.S. Foreign Direct Investment

The United States foreign direct investment is extracted from the Bureau of Economic Analysis, and defined as the United States direct investment abroad on a historical-cost basis, by country and industry in millions of U.S. dollars. The industries are divided into high-skilled and low-skilled according to the categorization in Tables 11 and 12.

1.6. Offshoring Technology

We use the number of internet users (per 100 people), and the mobile cellular phone subscriptions (per 100 people), as proxies for the offshoring technology. This data is extracted from the World Development Indicators.

2. Derivations

2.1. Proof of Proposition 1

Assume that $s^* > s^{**}$, and $w^* > w^{**}$. The skill premium in the South is given by

$$w^S = \frac{\left(\frac{\bar{h}^*}{H^*}\right)s^{**} + \left(1 - \frac{\bar{h}^*}{H^*}\right)s^*}{\left(\frac{l^*}{L^*}\right)w^{**} + \left(1 - \frac{l^*}{L^*}\right)w^*}.$$

Assume that $\beta_{LX} = \beta_{LY} = \beta_{HX} = \beta_{HY} = \beta$. Taking the derivative of w^S with respect to β yields

$$\frac{\partial w^S}{\partial \beta} = \left[\frac{s^*}{\left(\frac{l^*}{L^*}\right)w^{**} + \left(1-\frac{l^*}{L^*}\right)w^*}\right]\left[\frac{\partial\left(1-\frac{\bar{h}^*}{H^*}\right)}{\partial \beta}\right]$$
$$-\frac{\left[\left(\frac{\bar{h}^*}{H^*}\right)s^{**} + \left(1-\frac{\bar{h}^*}{H^*}\right)s^*\right]w^*}{\left[\left(\frac{l^*}{L^*}\right)w^{**} + \left(1-\frac{l^*}{L^*}\right)w^*\right]^2}\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial \beta}\right].$$

If $\frac{\partial w^S}{\partial \beta} > 0$, this means that as the offshoring technology improves $(d\beta < 0)$, the skill premium in the South declines. This derivative is positive if and only if

$$\left[\frac{s^*}{\left(\frac{l^*}{L^*}\right)w^{**} + \left(1-\frac{l^*}{L^*}\right)w^*}\right]\left[\frac{\partial\left(1-\frac{\bar{h}^*}{H^*}\right)}{\partial \beta}\right] > \frac{\left[\left(\frac{\bar{h}^*}{H^*}\right)s^{**} + \left(1-\frac{\bar{h}^*}{H^*}\right)s^*\right]w^*}{\left[\left(\frac{l^*}{L^*}\right)w^{**} + \left(1-\frac{l^*}{L^*}\right)w^*\right]^2}\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial \beta}\right],$$

which can be simplified to

$$s^*\left[\frac{\partial\left(1-\frac{\bar{h}^*}{H^*}\right)}{\partial \beta}\right] > \frac{\left[\left(\frac{\bar{h}^*}{H^*}\right)s^{**} + \left(1-\frac{\bar{h}^*}{H^*}\right)s^*\right]w^*}{\left[\left(\frac{l^*}{L^*}\right)w^{**} + \left(1-\frac{l^*}{L^*}\right)w^*\right]}\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial \beta}\right],$$

which can be rearranged to

$$\frac{s^*}{w^*} > w^S \frac{\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial \beta}\right]}{\left[\frac{\partial\left(1-\frac{\bar{h}^*}{H^*}\right)}{\partial \beta}\right]}. \tag{21}$$

This also means that $\frac{\partial w^S}{\partial \beta} < 0$ if and only if

$$\frac{s^*}{w^*} < w^S \frac{\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial\beta}\right]}{\left[\frac{\partial\left(1-\frac{\bar{h}^*}{H^*}\right)}{\partial\beta}\right]}. \tag{22}$$

The left-hand side of (21) is independent of $\left(\frac{H^*}{L^*}\right)$. On the other hand, the right-hand side is a function of the skill abundance in the South $\left(\frac{H^*}{L^*}\right)$. It remains to determine the sign of the derivative of the right-hand side with respect to $\left(\frac{H^*}{L^*}\right)$. First, the skill premium in the South can be rewritten as

$$w^S = \left[\frac{\left(\frac{\bar{h}^*}{L^*}\right)\left(s^{**}-s^*\right)+\left(\frac{H^*}{L^*}\right)s^*}{\left(\frac{l^*}{L^*}\right)\left(w^{**}-w^*\right)+w^*}\right]\left(\frac{H^*}{L^*}\right)^{-1}.$$

Thus, the derivative of the skill premium with respect to skill abundance $\left(\frac{H^*}{L^*}\right)$ is given by

$$\frac{\partial w^S}{\partial\left(\frac{H^*}{L^*}\right)} = \left[\frac{\left(\frac{\bar{h}^*}{L^*}\right)\left(s^{**}-s^*\right)+\left(\frac{H^*}{L^*}\right)s^*}{\left(\frac{l^*}{L^*}\right)\left(w^{**}-w^*\right)+w^*}\right]\left(\frac{H^*}{L^*}\right)^{-2} + \left(\frac{H^*}{L^*}\right)^{-1}\left[\frac{s^*}{\left(\frac{l^*}{L^*}\right)\left(w^{**}-w^*\right)+w^*}\right].$$

This is positive if and only if

$$\left(\frac{H^*}{L^*}\right)^{-1}\left[\frac{s^*}{\left(\frac{l^*}{L^*}\right)\left(w^{**}-w^*\right)+w^*}\right]>\left[\frac{\left(\frac{\overline{h}^*}{L^*}\right)\left(s^{**}-s^*\right)+\left(\frac{H^*}{L^*}\right)s^*}{\left(\frac{l^*}{L^*}\right)\left(w^{**}-w^*\right)+w^*}\right]\left(\frac{H^*}{L^*}\right)^{-2}.$$

This can be simplified to

$$\left(\frac{H^*}{L^*}\right)s^*>\left(\frac{\overline{h}^*}{L^*}\right)\left(s^{**}-s^*\right)+\left(\frac{H^*}{L^*}\right)s^*.$$

Which can be further simplified to

$$\left(\frac{\overline{h}^*}{L^*}\right)s^*>\left(\frac{\overline{h}^*}{L^*}\right)s^{**},$$

which is true since we assumed $s^*>s^{**}$. Therefore, the skill premium increases with skill abundance. In addition, we also know that $\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial\beta}\right]$ and $\left[\frac{\partial\left(1-\frac{\overline{h}^*}{H^*}\right)}{\partial\beta}\right]$ increasing in $\left(\frac{H^*}{L^*}\right)$. This means that the right-hand side of (21) is increasing in $\left(\frac{H^*}{L^*}\right)$. Therefore, since the left-hand side is independent of $\left(\frac{H^*}{L^*}\right)$, there exists a threshold, $\left(\frac{H^*}{L^*}\right)^T$, that satisfies

$$\frac{s^*}{w^*} = w^S \frac{\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta}\right]}{\left[\dfrac{\partial\left(1-\dfrac{\bar{h}^*}{H^*}\right)}{\partial\beta}\right]}.$$

Below this threshold, skill abundance is lower than the threshold, and accordingly the right-hand side is lower than the left-hand side, and the condition (21) is satisfied, such that $\frac{\partial w^S}{\partial\beta} > 0$, and an improvement in the offshoring technology causes a decrease in the skill premium. Above the threshold, skill abundance is higher than the threshold and accordingly the right-hand side is higher than the left-hand side, and the condition (22) is satisfied, such that $\frac{\partial w^S}{\partial\beta} < 0$, and an improvement in the offshoring technology causes an increase in the skill premium.

2.2. Proof of Proposition 2

Assume that the wages in the local production catch up with those in the offshoring sector, such that $s^* = s^{**}$, and $w^* = w^{**}$. Assume also that $\beta_{LX} = \beta_{LY} = \beta_{HX} = \beta_{HY} = \beta$. As in proposition 1, the derivative of w^S with respect to β is zero if and only if

$$\frac{s^*}{w^*} = w^S \frac{\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta}\right]}{\left[\dfrac{\partial\left(1-\dfrac{\bar{h}^*}{H^*}\right)}{\partial\beta}\right]}. \qquad (23)$$

If $s^{**} = s^*$, $w^{**} = w^*$, then $w^S = \dfrac{s^*}{w^*}$. Therefore, condition (23) is satisfied if and only if $\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta}\right] = \left[\dfrac{\partial\left(1-\dfrac{\bar{h}^*}{H^*}\right)}{\partial\beta}\right]$, which can be written as

$$\int_0^{I_{LX}} t_{LX}(i)\frac{a_{LX}}{L^*}di + \int_0^{I_{LY}} t_{LY}(i)\frac{a_{LY}}{L^*}di = \int_0^{I_{HX}} t_{HX}(i)\frac{a_{HX}}{H^*}di + \int_0^{I_{HY}} t_{HY}(i)\frac{a_{HY}}{H^*}di,$$

$$\frac{H^*}{L^*} = \frac{\int_0^{I_{HX}} t_{HX}(i)a_{HX}di + \int_0^{I_{HY}} t_{HY}(i)a_{HY}di}{\int_0^{I_{LX}} t_{LX}(i)a_{LX}di + \int_0^{I_{LY}} t_{LY}(i)a_{LY}di}. \tag{24}$$

Therefore, we can conclude that if $s^* = s^{**}$, $w^* = w^{**}$, and (24) are satisfied, any change in the technology of offshoring will not affect wage inequality at this level of skill abundance. We denote this threshold level of skill abundance as $\left(\dfrac{H^*}{L^*}\right)^{TT}$.

On the other hand, if $\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta}\right] < \left[\dfrac{\partial\left(1-\dfrac{\bar{h}^*}{H^*}\right)}{\partial\beta}\right]$, then $\dfrac{H^*}{L^*} < \left(\dfrac{H^*}{L^*}\right)^{TT}$, and $\dfrac{s^*}{w^*} > w^S \dfrac{\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta}\right]}{\left[\dfrac{\partial\left(1-\dfrac{\bar{h}^*}{H^*}\right)}{\partial\beta}\right]}$. This implies $\dfrac{\partial w^S}{\partial\beta} > 0$, and the skill premium declines after an improvement in the technology of offshoring. If we assume that

$\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial\beta}\right] \le \left[\frac{\partial\left(1-\frac{\overline{h}^*}{H^*}\right)}{\partial\beta}\right]$, and that $s^{**} \le s^*$, $w^{**} \le w^*$, then $\frac{\partial w^S}{\partial\beta} > 0$ is not possible. In this context, $\left[\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial\beta}\right] \le \left[\frac{\partial\left(1-\frac{\overline{h}^*}{H^*}\right)}{\partial\beta}\right]$, if and only if

$$\frac{(a_{LX}+a_{LY})\int_0^{I_L} t_L(i)di}{L^*} \le \frac{(a_{HX}+a_{HY})\int_0^{I_H} t_H(i)di}{H^*}. \tag{25}$$

since $t_{LX}(i)=t_{LY}(i)=t_L(i)$, and $t_{HX}(i)=t_{HY}(i)=t_H(i)$, as we assumed $\beta_{LX}=\beta_{LY}$ $=\beta_{HX}=\beta_{HY}=\beta$. According to (25), the proportion of low-skilled workers engaged in offshoring activities amongst all low-skilled workers, is at most equal to the proportion of high-skilled workers engaged in offshoring activities amongst all high-skilled workers. This condition guarantees that there is a level of skill abundance, below which an improvement in the technology of offshoring causes a decrease in the skill premium, while offshoring does not affect the skill premium at this level.

2.3. Proof of Proposition 3

The skill premium in the South is given by

$$w^S = \frac{\left(\frac{\overline{h}^*}{H^*}\right)s^{**} + \left(1-\frac{\overline{h}^*}{H^*}\right)s^*}{\left(\frac{l^*}{L^*}\right)w^{**} + \left(1-\frac{l^*}{L^*}\right)w^*}.$$

Assume that $\beta_{LX}=\beta_{HX}=\beta_X$, and $\beta_{LY}=\beta_{HY}=\beta_Y$. The derivative of w^S with respect to β_X is given by

$$\frac{\partial w^S}{\partial \beta_X} = \left[\frac{s^*}{\left(\frac{l^*}{L^*}\right) w^{**} + \left(1 - \frac{l^*}{L^*}\right) w^*} \right] \left[\frac{\partial \left(1 - \frac{\bar{h}^*}{H^*}\right)}{\partial \beta_X} \right]$$
$$- \frac{\left[\left(\frac{\bar{h}^*}{H^*}\right) s^{**} + \left(1 - \frac{\bar{h}^*}{H^*}\right) s^*\right] w^*}{\left[\left(\frac{l^*}{L^*}\right) w^{**} + \left(1 - \frac{l^*}{L^*}\right) w^*\right]^2} \left[\frac{\partial \left(1 - \frac{l^*}{L^*}\right)}{\partial \beta_X} \right].$$

If $\frac{\partial w^S}{\partial \beta_X} > 0$, this means that as the offshoring technology of the high-skilled intensive industry improves $(d\beta_X < 0)$, the skill premium in the South declines. This derivative is positive if and only if

$$\left[\frac{s^*}{\left(\frac{l^*}{L^*}\right) w^{**} + \left(1 - \frac{l^*}{L^*}\right) w^*} \right] \left[\frac{\partial \left(1 - \frac{\bar{h}^*}{H^*}\right)}{\partial \beta_X} \right] > \frac{\left[\left(\frac{\bar{h}^*}{H^*}\right) s^{**} + \left(1 - \frac{\bar{h}^*}{H^*}\right) s^*\right] w^*}{\left[\left(\frac{l^*}{L^*}\right) w^{**} + \left(1 - \frac{l^*}{L^*}\right) w^*\right]^2} \left[\frac{\partial \left(1 - \frac{l^*}{L^*}\right)}{\partial \beta_X} \right],$$

which can be simplified to

$$\frac{s^*}{w^*} > w^S \frac{\left[\frac{\partial \left(1 - \frac{l^*}{L^*}\right)}{\partial \beta_X} \right]}{\left[\frac{\partial \left(1 - \frac{\bar{h}^*}{H^*}\right)}{\partial \beta_X} \right]} = w^S \left[\left(\frac{a_{LX}}{a_{HX}}\right) \frac{\int_0^{I_{LX}} t_{LX}(i) di}{\int_0^{I_{HX}} t_{HX}(i) di} \right]. \tag{26}$$

As in proposition 1, this implies that there is a threshold skill abundance $\left(\frac{H^*}{L^*}\right)^{TX}$, below which the skill premium in the South declines with an improvement in the technology of offshoring all tasks in the high-skilled intensive industry, and above which the skill premium increases. Similarly, the derivative of w^S with respect to β_Y is given by

$$\frac{\partial w^S}{\partial \beta_Y} = \left[\frac{s^*}{\left(\frac{l^*}{L^*}\right)w^{**} + \left(1 - \frac{l^*}{L^*}\right)w^*}\right]\left[\frac{\partial\left(1 - \frac{\bar{h}^*}{H^*}\right)}{\partial \beta_Y}\right]$$
$$- \frac{\left[\left(\frac{\bar{h}^*}{H^*}\right)s^{**} + \left(1 - \frac{\bar{h}^*}{H^*}\right)s^*\right]w^*}{\left[\left(\frac{l^*}{L^*}\right)w^{**} + \left(1 - \frac{l^*}{L^*}\right)w^*\right]^2}\left[\frac{\partial\left(1 - \frac{l^*}{L^*}\right)}{\partial \beta_Y}\right].$$

If $\frac{\partial w^S}{\partial \beta_Y} > 0$, this means that as the offshoring technology of the low-skilled intensive industry improves $(d\beta_Y < 0)$, the skill premium in the South declines. This derivative is positive if and only if

$$\left[\frac{s^*}{\left(\frac{l^*}{L^*}\right)w^{**} + \left(1 - \frac{l^*}{L^*}\right)w^*}\right]\left[\frac{\partial\left(1 - \frac{\bar{h}^*}{H^*}\right)}{\partial \beta_Y}\right] > \frac{\left[\left(\frac{\bar{h}^*}{H^*}\right)s^{**} + \left(1 - \frac{\bar{h}^*}{H^*}\right)s^*\right]w^*}{\left[\left(\frac{l^*}{L^*}\right)w^{**} + \left(1 - \frac{l^*}{L^*}\right)w^*\right]^2}\left[\frac{\partial\left(1 - \frac{l^*}{L^*}\right)}{\partial \beta_Y}\right],$$

which can be simplified to

$$\frac{s^*}{w^*} > w^S \frac{\left[\frac{\partial\left(1 - \frac{l^*}{L^*}\right)}{\partial \beta_Y}\right]}{\left[\frac{\partial\left(1 - \frac{\bar{h}^*}{H^*}\right)}{\partial \beta_Y}\right]} = w^S \left[\left(\frac{a_{LY}}{a_{HY}}\right)\frac{\int_0^{I_{LY}} t_{LY}(i)di}{\int_0^{I_{HY}} t_{HY}(i)di}\right]. \tag{27}$$

As in proposition 1, this implies that there is a threshold skill abundance $\left(\frac{H^*}{L^*}\right)^{TY}$, below which the skill premium in the South declines with an improvement in the technology of offshoring all tasks in the high-skilled intensive industry, and above which the skill premium increases.

We already assumed that $\frac{a_{HX}}{a_{LX}} > \frac{a_{HY}}{a_{LY}}$, and that $\frac{\int_0^{I_{LX}} t_{LX}(i)di}{\int_0^{I_{HX}} t_{HX}(i)di} < \frac{\int_0^{I_{LY}} t_{LY}(i)di}{\int_0^{I_{HY}} t_{HY}(i)di}$, which means that the gap between the labor requirement for all *H*-tasks and all *L*-tasks in the high-skilled intensive industry is higher than that in the low-skilled intensive industry. This means that the second term in the right-hand side in (26) is smaller than that in the right-hand side in (27). This also means that the equalities that determines the two thresholds imply that $\left(\frac{H^*}{L^*}\right)^{TX} > \left(\frac{H^*}{L^*}\right)^{TY}$, since $\frac{\partial w^S}{\partial\left(\frac{H^*}{L^*}\right)} > 0$.

2.4. Proof of Proposition 4

Assume that $s^* = s^{**}$, and $w^* = w^{**}$. Assume also that $\beta_{LX} = \beta_{HX} = \beta_X$, and $\beta_{LY} = \beta_{HY} = \beta_Y$. As in proposition 3, the derivative of w^S with respect to β_X is zero if and only if

$$\frac{s^*}{w^*} = w^S \frac{\left[\frac{\partial\left(1 - \frac{l^*}{L^*}\right)}{\partial \beta_X}\right]}{\left[\frac{\partial\left(1 - \frac{\bar{h}^*}{H^*}\right)}{\partial \beta_X}\right]}.$$

This is satisfied if and only if $\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta_X}\right]=\left[\dfrac{\partial\left(1-\dfrac{\overline{h}^*}{H^*}\right)}{\partial\beta_X}\right]$. We know that

$$\frac{\partial\left(1-\frac{l^*}{L^*}\right)}{\partial\beta_X}=\int_0^{I_{LX}} t_{LX}(i)\frac{a_{LX}}{L^*}di\ ,$$

$$\frac{\partial\left(1-\frac{\overline{h}^*}{H^*}\right)}{\partial\beta_X}=\int_0^{I_{HX}} t_{HX}(i)\frac{a_{HX}}{H^*}di\ .$$

Thus, $\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta_X}\right]=\left[\dfrac{\partial\left(1-\dfrac{\overline{h}^*}{H^*}\right)}{\partial\beta_X}\right]$ if and only if

$$\frac{H^*}{L^*}=\frac{\int_0^{I_{HX}} t_{HX}(i)a_{HX}\,di}{\int_0^{I_{LX}} t_{LX}(i)a_{LX}\,di}\ . \tag{28}$$

Therefore, we can conclude that if $s^{**}=s^*$, $w^{**}=w^*$, and (28) are satisfied, any change in offshoring of tasks in the high-skilled intensive good will not affect wage inequality. We denote this level of skill abundance as $\left(\dfrac{H^*}{L^*}\right)^{TTX}$. As in proposition 2, we also assume that $\dfrac{\int_0^{I_{LX}} t_{LX}(i)a_{LX}\,di}{L^*}\le\dfrac{\int_0^{I_{HX}} t_{HX}(i)a_{HX}\,di}{H^*}$.

Similarly, the derivative of w^S with respect to β_Y is zero if and only if

$$\frac{s^*}{w^*} = w^S \frac{\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta_Y}\right]}{\left[\dfrac{\partial\left(1-\dfrac{\overline{h}^*}{H^*}\right)}{\partial\beta_Y}\right]} .$$

This is satisfied if and only if $\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta_Y}\right] = \left[\dfrac{\partial\left(1-\dfrac{\overline{h}^*}{H^*}\right)}{\partial\beta_Y}\right]$. We know that

$$\frac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta_Y} = \int_0^{I_{LY}} t_{LY}(i)\frac{a_{LY}}{L^*}\,di ,$$

$$\frac{\partial\left(1-\dfrac{\overline{h}^*}{H^*}\right)}{\partial\beta_Y} = \int_0^{I_{HY}} t_{HY}(i)\frac{a_{HY}}{H^*}\,di .$$

Thus, $\left[\dfrac{\partial\left(1-\dfrac{l^*}{L^*}\right)}{\partial\beta_Y}\right] = \left[\dfrac{\partial\left(1-\dfrac{\overline{h}^*}{H^*}\right)}{\partial\beta_Y}\right]$ if and only if

$$\frac{H^*}{L^*} = \frac{\int_0^{I_{HY}} t_{HY}(i)a_{HY}di}{\int_0^{I_{LY}} t_{LY}(i)a_{LY}di} . \tag{29}$$

Therefore, we can conclude that if $s^{**} = s^*$, $w^{**} = w^*$, and (29) are satisfied, any change in offshoring of tasks in the low-skilled intensive good will not affect wage inequality. We denote this level of skill abundance as $\left(\frac{H^*}{L^*}\right)^{TTY}$. As in proposition 2, we also assume that $\frac{\int_0^{I_{LY}} t_{LY}(i)a_{LY}di}{L^*} \leq \frac{\int_0^{I_{HY}} t_{HY}(i)a_{HY}di}{H^*}$.

We already assumed that $\frac{a_{HX}}{a_{LX}} > \frac{a_{HY}}{a_{LY}}$, and that $\frac{\int_0^{I_{LX}} t_{LX}(i)di}{\int_0^{I_{HX}} t_{HX}(i)di} < \frac{\int_0^{I_{LY}} t_{LY}(i)di}{\int_0^{I_{HY}} t_{HY}(i)di}$. Therefore $\left(\frac{H^*}{L^*}\right)^{TTX} > \left(\frac{H^*}{L^*}\right)^{TTY}$, since $\frac{\int_0^{I_{HX}} t_{HX}(i)a_{HX}di}{\int_0^{I_{LX}} t_{LX}(i)a_{LX}di} > \frac{\int_0^{I_{HY}} t_{HY}(i)a_{HY}di}{\int_0^{I_{LY}} t_{LY}(i)a_{LY}di}$.

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Received October 23, 2009, Revised January 29, 2010, Accepted June 15, 2010.