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**WOULD OUTSOURCING INCREASE OR DECREASE WAGE INEQUALITY? TWO MODELS,
TWO ANSWERS**

Wenli Cheng and Dingsheng Zhang

ABSTRACT

This paper develops two models to study the impact of outsourcing on wage inequality between skilled and unskilled labor in the developed country and the developing country. The first model assumes symmetric production technologies in both countries, and predicts that outsourcing will increase wage inequality in the developed country, but decrease wage inequality in the developing country. The second model assumes asymmetric technologies in the production of the intermediate good and predicts that outsourcing can lead to an increase in wage inequality in both the developed country and the developing country.

Key words: wage inequality, endogenous outsourcing

JEL classification: F19

WOULD OUTSOURCING INCREASE OR DECREASE WAGE INEQUALITY? TWO MODELS, TWO ANSWERS

1. INTRODUCTION

In the past few decades, the widening of the wage gap has been observed in many countries including some developing countries. During the same period, the world economy has become increasingly integrated through the rapid expansion of trade in intermediate goods (outsourcing) as well as in final goods. Has the growth in outsourcing and in final-goods trade contributed to the rise in wage inequality? This is a significant policy issue that has generated considerable debate. However, the debate to date appears to have focused on the relationship between trade (in final goods) and wage inequality, and the impact of outsourcing has received little attention (Feenstra and Gordon, 1996).

With respect to rising wage inequality in developed countries, two main explanations have been put forward in the literature. The first is based on the familiar Hechscher-Ohin theory which predicts that trade expansion will lead to a contraction of the import-competing sector, which, in a developed country, is the sector that uses unskilled labor more intensively. Consequently, the demand for unskilled labor will fall, so will the relative wage of the unskilled. The second explanation is that technology development has exhibited a bias against the use of unskilled labor, leading to a decline in the relative demand for unskilled labor, thus lowering their relative wage. There is considerable debate over the magnitude or importance of the trade effects relative to skill-biased technology. Some believe the trade is a main source of the widening gap between skilled and unskilled labor (see for instance, Thurow, 1992, Leamer 1996). Others argue that technological development is a more plausible cause of the decline in the relative position of the unskilled (see for instance, Bound and Johnson, 1992, and Berman et al, 2004). Despite the disagreement over the magnitude of the trade effects, there seems to be a consensus over the direction of the trade effects, namely, that trade has the effect of increasing wage inequality in developed countries (Wood, 1997).

With respect to wage inequality in developing countries, the Hechscher-Ohin theory predicts that a trade expansion will reduce wage inequality. This is because following a trade expansion, the export sector, which is intensive in unskilled labor, will expand, as a result the relative demand for unskilled labor will increase, leading to a rise in the relative wage for the unskilled. However this prediction is not borne out in reality. Empirical studies have found that while wage inequality has fallen in some developing countries, it has risen in others. For instance, Das (2002) finds that wage inequality has increased in Mexico and Chile, but decreased in the Philippines, Singapore

and Taiwan. Robbins (1996) shows that wage gap grew with trade liberalization in Chile, Columbia, Costa Rica and Argentina, though fell in Malaysia and the Philippines. Wood (1997) also reports that while the East Asian experience was in line with the Heckscher-Ohlin theory's prediction of falling inequality in developing countries, the experience in Latin American presented a challenge to that conventional wisdom. According to Wood, when openness increased, wage gap narrowed in Korea, Taiwan and Singapore, but widened in Argentina, Chile, Colombia, Costa Rica, Uruguay and Mexico.

What may be the reasons behind rising wage inequality in developing countries? Feenstra and Hanson (1995) suggest that rising wage inequality in Mexico was linked to an increase in foreign direct investment. They construct a model in which a growth of the relative capital stock in the South will raise the critical ratio dividing the Northern and Southern activities. The activities transferred from the North to the South is unskilled labor-intensive by Northern standards but skilled labor-intensive by Southern standards, therefore the transfer raises relative demand for skilled labor in both countries. Inspired by Feenstra and Hanson (1995), Zhu and Trefler (2005) conjecture that the trends in wage inequality across developing countries can be explained by changes in trade patterns triggered by technological catch-up. In their model, technological catch-up by the South causes production of the least skill-intensive Northern goods to migrate South where they become the most skill-intensive Southern good, thereby increasing wage inequality in both countries. There are other explanations of rising inequality in developing countries. Notably, Either (2005) points to the complementarity between equipment and skilled labor, that is, when a developing country imports equipment, the demand for skilled labor also increases. Beaulieu et al. (2004) hypothesize that the removal of trade barriers can raise the relative price for high-tech products, which can cause greater wage inequality in both countries through the Stolper-Samuelson channel.

Building on the existing literature, this paper aims to make two contributions. Firstly, it develops two general equilibrium models that examine the impact of international outsourcing (outsourcing for short hereafter) on wage inequality in both the developed country and the developing country. Both models have the following two features:

1. Due to positive transaction costs associated with outsourcing, there is a trade-off between transaction costs savings and gains from outsourcing. Consequently outsourcing is endogenously determined in both models, that is, outsourcing occurs in equilibrium only when the gains from outsourcing outweigh the transaction costs associated with it.
2. Each model considers two general equilibrium trade structures: a structure with trade in only final goods, and a structure with trade in both final and intermediate goods. This

allows us to examine the impact of outsourcing on wage inequality explicitly and separately from the impact of trade in final goods.

The second contribution of this paper is to offer an explanation for why outsourcing may increase wage inequality in some developing countries, while decrease it in others. Our first model assumes symmetry in production technology in developed and developing countries, and predicts that outsourcing will decrease wage inequality in the developing country because the outsourced intermediate good is intensive in unskilled labor. In comparison, our second model assumes asymmetry in production technologies for the intermediate good. Specifically, we assume that the intermediate good is produced with unskilled labor in the developed country but produce with skilled labor in the developing country. This assumption is a variation of Feenstra and Hanson's (1995) assumption that activities migrated to the South are unskilled labor-intensive in the North which becomes skilled labor-intensive in the South. With the assumption of asymmetric production technology, outsourcing by the developed country will lower the relative demand for unskilled labor in the developed country and raise the relative demand for skilled labor in the developing country, thereby increasing wage inequality in both countries.

In the following, we first present Model 1 with symmetric production functions in both countries, and discuss the impact of outsourcing on wage inequality. Then we present Model 2 with asymmetric production functions and explain how outsourcing may increase wage inequality in the developing country. The main results of the paper are summarized in the concluding section.

2. MODEL 1: A MODEL WITH SYMMETRIC PRODUCTION FUNCTIONS

Consider a world economy consisting of a developed country, country 1, and a developing country, country 2. Each country is endowed with skilled workers L_{is} and unskilled workers L_{iu} ($i = 1, 2$). Migration between countries is prohibitively expensive. There are two final goods, Y and Z, and an intermediate good X which is used in the production of Good Y.

2.1. Consumer decision

There are two types of consumers in each country, the skilled-worker and the unskilled-worker. An individual consumer is assumed to be endowed with one unit of labor which is sold for a wage. The consumer uses the wage to buy the two final goods Y and Z from either the domestic market or the foreign market. The decision problems for the two types of consumers in country i are, respectively

$$\begin{aligned} \text{Max: } u_{is} &= (y_i + y_{ji})^\alpha (z_i + z_{ji})^{1-\alpha} \\ \text{s.t. } p_y y_i + p_y y_{ji} + p_z z_i + p_z z_{ji} &= w_{is} \end{aligned}$$

and

$$\text{Max: } u_{iu} = (y_i + y_{ji})^\alpha (z_i + z_{ji})^{1-\alpha}$$

$$\text{s.t. } p_{iy} y_i + p_{iy} y_{ji} + p_{iz} z_i + p_{iz} z_{ji} = w_{iu}$$

where u_{is} and u_{iu} are the utility levels of the skilled-worker and the unskilled-worker in country i , respectively; y_i and z_i are the respective quantities of final goods Y and Z, purchased from the domestic market in country i ; y_{ji} and z_{ji} are the respective quantities of the good Y and Z imported; p_{iy} and p_{iz} are the prices of good Y and Z in country i .

If the price of an imported final good is lower, the consumer will buy imports; otherwise he/she will buy domestically. The decisions of consumers in both countries will determine the direction of trade flow in final goods. For example, if the price of good Y is lower in country 1, than consumers in country 1 will buy good Y domestically and consumers in country 2 will import good Y.

2.2. Producer decision

There may be up to three types of firms in a country each producing good Z, Y and X respectively. Each firm's decision problem is to choose the quantity of production to maximise profit. In addition, a Y-producing firm will decide whether to buy the intermediate good X domestically or to outsource it from another country. If it chooses to outsource, it will incur a transaction cost. Thus it will outsource good X only if the domestic price of good X is higher than the cost of outsourcing including the transaction costs.

The production technologies for the three goods Z, Y and X are as follows. Final good Z is a traditional good and is produced with both skilled and unskilled labor. The production function of good Z in country i is:

$$z_i = a_{iz} L_{iuz}^\gamma L_{isz}^{1-\gamma}$$

where L_{iuz} and L_{isz} are the respective amounts of unskilled labor and skilled allocated to the production of good Z in country i .

Final good Y is a more sophisticated good and is produced with skilled-labor, unskilled labor and an intermediate good X. The production function of good Y in country i is

$$y_i = a_{iy} (x_i + t_i x_{ji})^\beta L_{iuy}^\delta L_{isy}^{1-\beta-\delta}$$

where x_i is the quantity of the intermediate good X purchased domestically and x_{ji} is the quantity of good X imported; L_{iuy} and L_{isy} are the respective amount of unskilled and skilled labor used in producing good Y; t_i is the transaction efficiency coefficient for outsourcing good X by a Y-producing firm in country i . The specification of the transaction efficiency coefficient assumes that the outsourcing firm incurs an iceberg transaction cost, that is, for each unit of intermediate good X outsourced, the firm only receives t_i , a proportion $1-t_i$ is lost in transition. The size of the

transaction efficiency coefficient may be determined by a variety of factors, including search costs, transport costs, and the nature of the tariff regime.

The intermediate good X is produced with unskilled labor only. The production function for an intermediate good in country i is

$$x_i = a_{ix} L_{iux}$$

where L_{iux} is the amount of unskilled labor used in producing good X.

2.3. Equilibrium trade structures

The consumers' decision on whether or not to import a final good combined with the Y-producing firms' decision on whether or not to outsourcing determine the structure of trade. We consider two possible trade structures: (1) structure $(XY)_Y(Z)_Z$ where country 1 produces both good X and good Y and exports good Y, and country 2 produces and exports good Z; (2) structure $(Y)_Y(XZ)_{XZ}$ where Y-producing firms in country 1 outsource good X to produce good Y and exports good Y, and country 2 produces and exports good X and good Z.

In both trade structures, the developed country, country 1, exports the more sophisticated good Y and the developing country exports the traditional good Z. There is only trade in final good in structure $(XY)_Y(Z)_Z$, and there are both trade in final goods and international outsourcing in structure $(Y)_Y(XZ)_{XZ}$. Either structure can emerge as the general equilibrium structure under certain conditions (i.e., within certain defined parameter subsets). In the following, we solve the equilibrium prices for each structure and identify the corresponding parameter subsets within which each structure is the general equilibrium structure.

First we solve for the equilibrium prices for structure $(XY)_Y(Z)_Z$. In this structure, consumers in country 1 buy good Y domestically and import good Z; consumers in country 2 import good Y and buy good Z domestically. Thus the representative consumer's decision problem simplifies to:

$$\text{Country 1: Max: } u_1 = y_1^\alpha z_{21}^{1-\alpha}$$

$$\text{s.t. } p_{1y} y_1 + p_{2z} z_{21} = w_1$$

$$\text{Country 2: Max: } u_2 = y_{12}^\alpha z_2^{1-\alpha}$$

$$\text{s.t. } p_{1y} y_{12} + p_{2z} z_2 = w_2$$

where $w_i = w_{iu}$ for an unskilled worker, and $w_i = w_{is}$ for a skilled worker, $i = 1, 2$.

Solving above problems, we have the demand functions for good Y and good Z in both countries. They are:

$$y_1^d = \frac{\alpha w_1}{p_{1y}}, z_{21}^d = \frac{(1-\alpha)w_1}{p_{2z}}$$

$$y_{12}^d = \frac{\alpha w_2}{p_{1y}}, z_2^d = \frac{(1-\alpha)w_2}{p_{2z}}$$

On the supply side of structure $(XY)_Y(Z)_Z$, firms in country 1 produce good X and good Y, and firms in country 2 produce good Z. The decision problems for the representative firm producing each good are:

$$(1) \text{ Y-producing firm in country 1: } \max_{x_1, L_{1uy}, L_{1sy}} \pi_{1y} = p_{1y} a_{1y} x_1^\beta L_{1uy}^\delta L_{1sy}^{1-\beta-\delta} - p_{1x} x_1 - w_{1u} L_{1uy} - w_{1s} L_{1sy}.$$

$$(2) \text{ X-producing firm in country 1: } \max_{L_{1ux}} \pi_{1x} = p_{1x} a_{1x} L_{1ux} - w_{1u} L_{1ux}$$

$$(3) \text{ Z-producing firm in country 2: } \max_{L_{2uz}, L_{2sz}} \pi_{2z} = p_{2z} a_{2z} L_{2uz}^\gamma L_{2sz}^{1-\gamma} - w_{2u} L_{2uz} - w_{2s} L_{2sz}$$

In equilibrium, both consumers' utility and firms' profits are maximised, and all markets clear. The market clearing conditions are:

$$\text{Market for good Y: } \frac{\alpha(w_{1u} L_{1u} + w_{1s} L_{1s})}{p_{1y}} + \frac{\alpha(w_{2u} L_{2u} + w_{2s} L_{2s})}{p_{1y}} = a_{1y} x_1^\beta L_{1uy}^\delta L_{1sy}^{1-\beta-\delta}$$

$$\text{Market for good Z: } \frac{(1-\alpha)(w_{1u} L_{1u} + w_{1s} L_{1s})}{p_{2z}} + \frac{(1-\alpha)(w_{2u} L_{2u} + w_{2s} L_{2s})}{p_{2z}} = a_{2z} L_{2uz}^\gamma L_{2sz}^{1-\gamma}$$

$$\text{Market for good X: } x_1 = a_{1x} L_{1ux}$$

$$\text{Market for unskilled labor in country 1: } L_{1ux} + L_{1uy} = L_{1u}$$

$$\text{Market for skilled labor in country 1: } L_{1sy} = L_{1s}$$

$$\text{Market for unskilled labor in country 2: } L_{2uz} = L_{2u}$$

$$\text{Market for skilled labor in country 2: } L_{2sz} = L_{2s}$$

Solving the consumers and the firms' decision problems, and applying the market clearing conditions, we obtain the general equilibrium prices for structure $(XY)_Y(Z)_Z$. These are summarized as follows:*

$$w_{1u} = 1, w_{1s} = \frac{(1-\beta-\delta) L_{1u}}{\beta+\delta} \frac{L_{1u}}{L_{1s}}, w_{2u} = \frac{\gamma(1-\alpha) L_{1u}}{\alpha(\beta+\delta) L_{2u}}, w_{2s} = \frac{(1-\gamma)(1-\alpha) L_{1u}}{\alpha(\beta+\delta) L_{2s}},$$

$$p_{1x} = \frac{1}{a_{1x}}, p_{1y} = a_{1y}^{-1} a_{1x}^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} w_{1s}^{1-\beta-\delta}, p_{2z} = a_{2z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{2u}^\gamma w_{2s}^{1-\gamma},$$

* If a good is not produced in a country, there is no domestic price for that good. We have therefore calculated a shadow price which is the price that would be if the good were produced in that country.

$$p_{2x} = \frac{w_{2u}}{a_{2x}} \text{ (shadow price)}, \quad p_{2y} = a_{2y}^{-1} a_{2x}^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} w_{2u}^{\beta+\delta} w_{2s}^{1-\beta-\delta} \text{ (shadow price)},$$

$$p_{1z} = a_{1z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{1s}^{1-\gamma} \text{ (shadow price)}.$$

Following a similar procedure, we can solve the general equilibrium prices for structure $(Y)_Y(XZ)_{XZ}$.

These are summarised as follows.

$$w_{1u} = 1, \quad w_{1s} = \frac{(1-\beta-\delta) L_{1u}}{\delta L_{1s}}, \quad w_{2u} = \frac{\gamma(1-\alpha) + \alpha\beta}{\alpha\delta} \frac{L_{1u}}{L_{2u}}, \quad w_{2s} = \frac{(1-\gamma)(1-\alpha)}{\alpha\delta} \frac{L_{1u}}{L_{2s}},$$

$$p_{1x} = \frac{1}{a_{1x}} \text{ (shadow price)}, \quad p_{1y} = a_{1y}^{-1} a_{2x}^{-\beta} t_1^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} w_{1s}^{1-\beta-\delta} w_{2u}^{\beta},$$

$$p_{1z} = a_{1z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{1s}^{1-\gamma} \text{ (shadow price)}, \quad p_{2x} = \frac{w_{2u}}{a_{2x}},$$

$$p_{2y} = a_{2y}^{-1} a_{2x}^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} w_{2u}^{\beta+\delta} w_{2s}^{1-\beta-\delta} \text{ (shadow price)}, \quad p_{2z} = a_{2z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{2u}^{\gamma} w_{2s}^{1-\gamma}.$$

2.4. Conditions for general equilibrium

In the above we have obtained the equilibrium prices for structure $(XY)_Y(Z)_Z$ and structure $(Y)_Y(XZ)_{XZ}$. For either of the structure to emerge in general equilibrium, certain parameter conditions must be met. In other words, each structure can be the general equilibrium structure only within a specific parameter subset. We derive the parameter subsets for the two structures below.

Essentially the parameter subsets are defined by consumers' decision to buy domestically or to import, and by firms' decision to buy intermediate inputs domestically or to outsource. A consumer will only import if the price in the other country is lower, and a firm will only outsource if the price of the intermediate input in the other country is lower after the transaction costs associated with outsourcing are taken into account. Thus, for structure $(XY)_Y(Z)_Z$ to emerge in equilibrium, it has to be true that the price of X (after transaction costs are taken into account) and the price of Y are lower in country 1, and the price of Z is lower in country 2. Similarly for structure $(Y)_Y(XZ)_{XZ}$ to emerge in equilibrium, it has to be true that the price of Y is lower in country 1, and the price of X (after transaction costs are taken into account) and the price Z are lower in country 2. Thus for each structure to be the general equilibrium structure, the corresponding conditions presented in Table 1 must be met.

Table 1: Conditions for equilibrium structures

Structure	Conditions
$(XY)_Y(Z)_Z$	$\frac{p_{1y}}{p_{2y}} < 1, \frac{p_{1z}}{p_{2z}} > 1, \frac{p_{1x}}{p_{2x}} < \frac{1}{t_1}$
$(Y)_Y(XZ)_{XZ}$	$\frac{p_{1y}}{p_{2y}} < \frac{p_{1z}}{p_{2z}}, \frac{p_{1x}}{p_{2x}} > \frac{1}{t_1}$

If we substitute the equilibrium prices into the conditions in Table 1, each set of the conditions expressed in parameters then defines the parameter subset within which a corresponding structure emerges as the general equilibrium structure. The parameter subsets are presented in Table 2 below.

Table 2: Parameter subsets for general equilibrium structures

Structure	Price subspace
$(XY)_Y(Z)_Z$	$\frac{a_{2y}}{a_{1y}} \left(\frac{a_{2x}}{a_{1x}} \right)^\beta \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\beta-\delta} \left(\frac{L_{2u}}{L_{1u}} \right)^{\beta+\delta} \frac{\alpha}{1-\alpha} \left(\frac{1-\beta-\delta}{1-\gamma} \right)^{1-\beta-\delta} \left(\frac{\beta+\delta}{\gamma} \right)^{\beta+\delta} < 1,$ $\frac{a_{2z}}{a_{1z}} \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\gamma} \left(\frac{L_{2u}}{L_{1u}} \right)^\gamma \frac{\alpha}{1-\alpha} \left(\frac{1-\beta-\delta}{1-\gamma} \right)^{1-\gamma} \left(\frac{\beta+\delta}{\gamma} \right)^\gamma > 1,$ $\frac{a_{2x}}{a_{1x}} \frac{\alpha}{1-\alpha} \frac{\beta+\delta}{\gamma} \frac{L_{2u}}{L_{1u}} < \frac{1}{t_1}$
$(Y)_Y(XZ)_{XZ}$	$\frac{a_{2y}}{a_{1y}} \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\beta-\delta} \left(\frac{L_{2u}}{L_{1u}} \right)^\delta \left(\frac{\alpha(1-\beta-\delta)}{(1-\gamma)(1-\alpha)} \right)^{1-\beta-\delta} \left(\frac{\delta\alpha}{\gamma(1-\alpha)+\alpha\beta} \right)^\delta < t_1^\beta,$ $\frac{a_{2z}}{a_{1z}} \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\gamma} \left(\frac{L_{2u}}{L_{1u}} \right)^\gamma \left(\frac{\alpha(1-\beta-\delta)}{(1-\gamma)(1-\alpha)} \right)^{1-\gamma} \left(\frac{\delta\alpha}{\gamma(1-\alpha)+\alpha\beta} \right)^\gamma > 1,$ $\frac{a_{2x}}{a_{1x}} \frac{\alpha\delta}{\alpha\beta+\gamma(1-\alpha)} \frac{L_{2u}}{L_{1u}} > \frac{1}{t_1}$

From the above table, we can see that t_1 increases, it is more likely that the conditions will be met for structure $(Y)_Y(XZ)_{XZ}$ to emerge as the general equilibrium structure. That is, as transaction efficiency associated with outsourcing increases due to, for example, improved transport technology, and/or lower tariff, it becomes more likely that the general equilibrium structure will feature outsourcing. Indeed, starting from structure $(XY)_Y(Z)_Z$ without outsourcing, if t_1 increases to some critical value, the general equilibrium structure will jump to structure $(Y)_Y(XZ)_{XZ}$. In other words, an improvement in transaction efficiency can endogenously induce the emergence of outsourcing. Since outsourcing is endogenously determined in our model, we can explicitly

analyse the impact of outsourcing on wage inequality. Specifically we can examine how the state of wage inequality will change if the general equilibrium structure shifts from a structure without outsourcing to a structure with outsourcing. This analysis is presented in the following.

2.5. The impact of outsourcing on wage inequality

We assume that an improvement in transaction efficiency has led to a change in the general equilibrium structure from structure $(XY)_Y(Z)_Z$ to structure $(Y)_Y(XZ)_{XZ}$. Assume further that the structural change is caused by the transaction efficiency improvement alone, that is, all other parameters remain unchanged.

We use the wage ratio between skilled and unskilled labor as a measure of wage inequality. If the ratio increases, wage inequality increases. Since the improvement in transaction efficiency causes the general equilibrium structure to change from one without outsourcing to one with outsourcing, the accompanied change in wage ratio between skilled and unskilled labor can be interpreted as the impact of outsourcing on wage inequality.

The wage ratios between skilled and unskilled labor in both countries in the two structures are presented in Table 3 below.

Table 3: Wage ratio between skilled and unskilled

Structure	Wage ratio between skilled and unskilled in country 1	Wage ratio between skilled and unskilled in country 2
$(XY)_Y(Z)_Z$	$\frac{(1-\beta-\delta)}{\beta+\delta} \frac{L_{1u}}{L_{1s}}$	$\frac{(1-\gamma)}{\gamma} \frac{L_{2u}}{L_{2s}}$
$(Y)_Y(XZ)_{XZ}$	$\frac{(1-\beta-\delta)}{\delta} \frac{L_{1u}}{L_{1s}}$	$\frac{(1-\gamma)(1-\alpha)}{\gamma(1-\alpha)+\alpha\beta} \frac{L_{2u}}{L_{2s}}$

From the above table, we can see wage ratio increases in country 1 and decreases in country 2 when economic structure jumps from structure $(XY)_Y(Z)_Z$ to structure $(Y)_Y(XZ)_{XZ}$. This suggests that outsourcing increases wage inequality in the developed country (country 1) and decreases wage inequality in the developing country. This result is consistent with the prediction of the standard HO model. However the mechanism through which outsourcing affects wage inequality in this model is different from that in the standard HO model. The standard HO model does not explicitly introduce outsourcing. Wage inequality increases in the developed country through the Stoper-Samuelson mechanism: the wage of skilled labor in the developed country is driven up by the increase in the price of the skilled labor-intensive good, and the wage of the unskilled labor in the

developing country is driven up by the increase in the price of the unskilled labor-intensive good. Notably prices of traded good are exogenous in the standard HO model. In contrast, in this model, the driving force for the emergence of outsourcing is improvement in transaction efficiency. As firms in the developed country choose to outsource the intermediate good which is produced with unskilled labor, the relative demand for unskilled labor falls, so does the relative wage for the unskilled. The reverse happens in the developing country which experiences an increase in relative demand for unskilled labor and a fall in wage inequality. Not only prices of traded goods but also outsourcing are endogenized in this model.

3. A MODEL WITH ASYMMETRIC PRODUCTION FUNCTIONS

In Model 1 we have assumed that the production function for the intermediate good X in the developing country is symmetrical to that in the developed country. In reality, the same product may be produced in different ways or by different segments of the labor force in different countries. In particular, in a developing country where the labor force is accustomed to producing traditional goods, when new opportunities for export open up, it is often the skilled workers who take the opportunities. For example, Feenstra and Hanson (1995) report that when US companies outsourced unskilled-labor intensive products from Mexico, these products were produced in a skilled labor-intensive fashion in Mexico, suggesting that the production functions for the outsourced good are asymmetrical in the US and Mexico.

Based on the insight of Feenstra and Hanson (1995), we propose Model 2, a model with asymmetrical production functions for the outsourced intermediate good, to analyse the impact of outsourcing on wage inequality.

The setup of Model 2 is the same as that of Model 1. Specifically, there are two countries, each with skilled and unskilled labor endowments. There are 2 consumption goods: a traditional good Z that can be produced with both skilled labor and unskilled labor in each country; and a more sophisticated good Y that can be produced with unskilled labor, skilled labor and an intermediate good X. The difference is that, in Model 2, the intermediate good X is produced with unskilled labor in country 1, the developed country, but is produced with skilled labor in country 2, the developing country.

3.1. Decision problems for consumers and firms

Similar to the case in Model 1, consumers choose whether to buy a good domestically or to import it, and decide on the quantities of consumption. The representative skilled and unskilled consumers' decision problems in country i are:

$$\text{Max: } u_{is} = (y_i + y_{ji})^\alpha (z_i + z_{ji})^{1-\alpha}$$

$$\text{s.t. } \rho_{iy} y_i + \rho_{jy} y_{ji} + \rho_{iz} z_i + \rho_{jz} z_{ji} = w_{is}$$

and

$$\text{Max: } u_{iu} = (y_i + y_{ji})^\alpha (z_i + z_{ji})^{1-\alpha}$$

$$\text{s.t. } \rho_{iy} y_i + \rho_{jy} y_{ji} + \rho_{iz} z_i + \rho_{jz} z_{ji} = w_{iu}$$

The notations are the same as those in Model 1.

Firms producing each type of good choose their output levels to maximize profit. The Y-producing firm has also to decide whether or not to outsource the intermediate product X. If it chooses to outsource, a transaction cost will be incurred. The production functions for final goods are the same as those in model 1. The production functions in country i are:

$$\text{Good Z: } z_i = a_{iz} L_{iuz}^\gamma L_{isz}^{1-\gamma}$$

$$\text{Good Y: } y_i = a_{iy} (x_i + t_i x_{ji})^\beta L_{iuy}^\delta L_{isy}^{1-\beta-\delta}$$

The production function for the intermediate good X in country 1 is

$$x_1 = a_{1x} L_{1ux}$$

whereas the production function for good X in country 2 is

$$x_2 = a_{2x} L_{2sx}$$

3.2. General equilibrium structure and conditions

As in Model 1, we consider two economic structures in Model 2: structure $(XY)_Y(Z)_Z$ in which country 1 exports Y in exchange for Z and there is no outsourcing; and structure $(Y)_Y(XZ)_{XZ}$ in which country 1 outsource good X to produce good Y, and exports good Y in exchange for good X and good Z.

The decision problems for consumers and firms in both structures and market clearing conditions are the same as in model 1. Solving the decision problems and applying the market clearing conditions, we obtain the equilibrium prices in both structures as follows.

Structure $(XY)_Y(Z)_Z$:

$$w_{1u} = 1, \quad w_{1s} = \frac{(1-\beta-\delta) L_{1u}}{\beta+\delta} \frac{L_{1u}}{L_{1s}}, \quad w_{2u} = \frac{\gamma(1-\alpha) L_{1u}}{\alpha(\beta+\delta) L_{2u}}, \quad w_{2s} = \frac{(1-\gamma)(1-\alpha) L_{1u}}{\alpha(\beta+\delta) L_{2s}},$$

$$p_{1x} = \frac{1}{a_{1x}}, \quad p_{1y} = a_{1y}^{-1} a_{1x}^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} w_{1s}^{1-\delta}, \quad p_{1z} = a_{1z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{1s}^{1-\gamma} \quad (\text{shadow price}).$$

$$p_{2x} = \frac{w_{2s}}{a_{2x}} \quad (\text{shadow price}), \quad p_{2y} = a_{2y}^{-1} a_{2x}^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} w_{2u}^\delta w_{2s}^{1-\delta} \quad (\text{shadow price}),$$

$$p_{2z} = a_{2z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{2u}^\gamma w_{2s}^{1-\gamma}$$

Structure $(Y)_Y(XZ)_{XZ}$:

$$w_{1u} = 1, \quad w_{1s} = \frac{(1-\beta-\delta) L_{1u}}{\delta L_{1s}}, \quad w_{2u} = \frac{\gamma(1-\alpha) L_{1u}}{\delta\alpha L_{2u}}, \quad w_{2s} = \frac{\alpha\beta + (1-\gamma)(1-\alpha) L_{1u}}{\delta\alpha L_{2s}},$$

$$p_{1x} = \frac{1}{a_{1x}} \text{ (shadow price)}, \quad p_{1y} = a_{1y}^{-1} a_{2x}^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} t_1^{-\beta} w_{2s}^\beta w_{1s}^{1-\beta-\delta},$$

$$p_{1z} = a_{1z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{1s}^{1-\gamma} \text{ (shadow price)},$$

$$p_{2x} = \frac{w_{2s}}{a_{2x}}, \quad p_{2y} = a_{2y}^{-1} a_{2x}^{-\beta} \beta^{-\beta} \delta^{-\delta} (1-\beta-\delta)^{\beta+\delta-1} w_{2u}^\delta w_{2s}^{1-\delta} \text{ (shadow price)},$$

$$p_{2z} = a_{2z}^{-1} \gamma^{-\gamma} (1-\gamma)^{\gamma-1} w_{2u}^\gamma w_{2s}^{1-\gamma}.$$

The conditions under which each of the two structures emerges as the general equilibrium structure are determined by the consumers decision on whether to buy a consumption good domestically or to import, and by the firms' decision on whether to buy the intermediate good domestically or to outsource. The conditions are expressed in terms of defined parameter subsets within which a structure is the general equilibrium structure. The parameter subsets are defined in Table 4 below.

Table 4. Parameter subsets for general equilibrium structures

Structure	Parameters subsets
$(XY)_Y(Z)_Z$	$\frac{a_{2y}}{a_{1y}} \left(\frac{a_{2x}}{a_{1x}} \right)^\beta \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\delta} \left(\frac{L_{2u}}{L_{1u}} \right)^\delta \frac{\alpha}{1-\alpha} \left(\frac{1-\beta-\delta}{1-\gamma} \right)^{1-\delta} \left(\frac{\beta+\delta}{\gamma} \right)^\delta < 1,$ $\frac{a_{2z}}{a_{1z}} \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\gamma} \left(\frac{L_{2u}}{L_{1u}} \right)^\gamma \frac{\alpha}{1-\alpha} \left(\frac{1-\beta-\delta}{1-\gamma} \right)^{1-\gamma} \left(\frac{\beta+\delta}{\gamma} \right)^\gamma > 1,$ $\frac{a_{2x}}{a_{1x}} \frac{\alpha}{1-\alpha} \frac{1-\beta-\delta}{1-\gamma} \frac{L_{2s}}{L_{1s}} < \frac{1}{t_1}$
$(Y)_Y(XZ)_{XZ}$	$\frac{a_{2y}}{a_{1y}} \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\beta-\delta} \left(\frac{L_{2u}}{L_{1u}} \right)^\delta \left(\frac{\alpha(1-\beta-\delta)}{\alpha\beta + (1-\gamma)(1-\alpha)} \right)^{1-\beta-\delta} \left(\frac{\delta\alpha}{\gamma(1-\alpha)} \right)^\delta < t_1^\beta,$ $\frac{a_{2z}}{a_{1z}} \left(\frac{L_{2s}}{L_{1s}} \right)^{1-\gamma} \left(\frac{L_{2u}}{L_{1u}} \right)^\gamma \left(\frac{\alpha(1-\beta-\delta)}{\alpha\beta + (1-\gamma)(1-\alpha)} \right)^{1-\gamma} \left(\frac{\delta\alpha}{\gamma(1-\alpha)} \right)^\gamma > 1,$ $\frac{a_{2x}}{a_{1x}} \frac{\alpha(1-\beta-\delta)}{\alpha\beta + (1-\gamma)(1-\alpha)} \frac{L_{2s}}{L_{1s}} > \frac{1}{t_1}$

As with Model 1, if the transaction efficiency coefficient t_1 increases to some critical value, the general equilibrium structure will jump from $(XY)_Y(Z)_Z$ to $(Y)_Y(XZ)_{XZ}$, and as a result, outsourcing will endogenously emerge. By comparing the wage ratios between skilled and unskilled labor in the two structures, we can examine the impact of outsourcing on wage inequality.

3.3. Impact of outsourcing on wage inequality

As in Model 1, we assume an improvement in transaction efficiency is the sole cause of a shift in the equilibrium structure from structure $(XY)_Y(Z)_Z$ to structure $(Y)_Y(XZ)_{XZ}$. As a result of the structural change, outsource emerges. The change in the wage ratio between the skilled and unskilled labor that accompanies the structural change is therefore interpreted as the impact of outsourcing on wage inequality. The wage ratios between skilled and unskilled labor in both countries in both structure are presented in Table 5.

Table 5: Wage ratio between skilled and unskilled labor

Structure	Wage ratio between skilled and unskilled labor in country 1	Wage ratio between skilled and unskilled labor in country 2
$(XY)_Y(Z)_Z$	$\frac{(1-\beta-\delta) L_{1u}}{\beta+\delta} \frac{L_{1u}}{L_{1s}}$	$\frac{(1-\gamma) L_{2u}}{\gamma} \frac{L_{2u}}{L_{2s}}$
$(Y)_Y(XZ)_{XZ}$	$\frac{(1-\beta-\delta) L_{1u}}{\delta} \frac{L_{1u}}{L_{1s}}$	$\frac{\alpha\beta+(1-\gamma)(1-\alpha) L_{2u}}{\gamma(1-\alpha)} \frac{L_{2u}}{L_{2s}}$

From the above table, we can see wage ratio increases in both countries as the general equilibrium structure shifts from structure $(XY)_Y(Z)_Z$ to structure $(Y)_Y(XZ)_{XZ}$, suggesting that outsourcing can increase wage inequality in the developing country as well as the developed country. This result contradicts the prediction of the standard HO model, but is consistent with empirical evidence from a number of Latin American countries as reported by Wood (1997). The key driver of this result is asymmetric production technologies for the intermediate good. Since the intermediate good is produced with unskilled labor in the developed country, but is produced with skilled labor in the developing country, outsourcing the intermediate good raises the relative demand for skilled labor in both countries, thereby increasing wage inequality in both countries. There seem to be some evidence that support both the result itself and the reason behind this result (see for instance, Feenstra and Hanson, 1995, and Wood, 1997).

4. CONCLUSION

In this paper, we have presented two models to study the impact of outsourcing on wage inequality between skilled and unskilled labor in the developed country and the developing country. The first model assumes symmetric production technologies in both countries, and predicts that outsourcing will increase wage inequality in the developed country, but decrease wage inequality in the developing country. This result is consistent with that of the traditional HO model, although the mechanism through which outsourcing affects wage inequality in our model is different in that it

highlights that improvement in transaction efficiency can endogenously induce the emergence of outsourcing which in turn changes the relative demand for skilled and unskilled labor in the trading countries, leading to changes in the wage ratio between the two types of labor. The second model assumes asymmetric technologies in the production of the intermediate good and predicts that outsourcing can lead to an increase in wage inequality in both the developed country and the developing country.

As discussed in the introduction, available empirical evidence seems to suggest that wage inequality has increased in some developing countries and decreased in others following increased outsourcing activities. The two models in this paper offer possible theoretical explanations for the different outcomes.

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