Technology Transfer, Welfare, and Factor Prices

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Abstract

We use a linear two-country-two-factor-two-product-two-different technology ($2 \times 2 \times 2 \times 2$) model to study technology transfer and its effects on each country's welfare and factor prices. We show that technology transfer could benefit both the recipient country and the transferring country. For the recipient country, we show that technology transfer increases the price of the factor that is more intensively used and decreases the price of the other factor. Our results provide an alternative explanation of the trend of the rise in real wage inequality between the relatively skilled workers and the less-skilled workers observed in the last half century due to technological progress across many countries.

Key words: Technology Transfer, Welfare, Factor Prices, FDI
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1 Introduction

Technology transfer (TT) between developed and developing countries has become an increasingly important part of international trade. TT can be in various forms. Developed countries with advanced technologies often invest in developing countries (called foreign direct investment, FDI in short). Sometimes developed countries may sell or transfer their advanced technologies to developing countries. Technology can also be in various forms, e.g., a blueprint, an efficient production plan, a machine, etc. Although a technology can be purchased or sold, it is different from a private good. It has a public good feature. For example, a country can share a technology without reducing its own use of it.

However, TT has not been well supported by everyone. One often wonders whether it is beneficial for a country with advanced production technology of a good to transfer the technology to another country. People against TT are concerned about job losses and wage decreases in the relevant industries. On the other hand, the literature has shown that overall, TT can benefit both the recipient country and the transferring country (e.g., Ruffin and Jones 2007, 2005).

In this paper, we use a simple linear two-country-two-factor-two-product-two-different technology ($2 \times 2 \times 2 \times 2$) model to study TT and its effects on each country's welfare and factor prices. First, we show that TT always raises the welfare of the recipient country and it may also raise the welfare of the transferring country (Theorem 1). We show that, for TT recipient country, if the TT leads to a more efficient use of the factor that is more intensively used in the production of the good, then this transfer will increase the factor price while decrease the other factor price (Theorem 2).

One important issue in both the developed countries and the developing countries is the rising wage inequality between skilled labor and unskilled labor in the past three decades. There are many studies on the causes of rising wage inequality. Two main causes have been identified, one is skill-biased technological progress (Feenstra and Hanson, 1999) and another is the international trade and investment (Feenstra and Hanson, 1996). Our Theorem 2 provides an alternative simple explanation about the impact of technological progress on wage inequality.

There are two separate strands in the literature on TT. One strand focuses on the welfare effects (who gains and who loses) of TT. For example, Ruffin and Jones (2007, 2005), Beladi, Jones, and Marjit (1997). This branch of literature all uses the standard one-factor Ricardian model. The main conclusion of this literature is that it is possible that both the transferring country and the recipient country may benefit from TT. The main drawback of this one-factor model is that it cannot examine the effect of TT on other production factors apart from labor.

Another strand of the literature examines *empirically* the effects of TT on factor prices (e.g., relative wages). In particular, this literature usually uses FDI as a proxy of TT and studies its impact on wage inequality between, e.g, skilled labor and the unskilled labor. In addition to Feenstra and Hanson (1997) who examine the wage inequality between skilled labor and unskilled labor in Mexico resulted from FDI, Wu (2000) does a similar study on wage inequality in China. In this paper, we propose a simple model that can be easily used to explain the effects of technology change on wage inequality as we have observed empirically.

We should also point out that there has been another entirely different branch of literature on TT that focuses on the documentation and classification of TT. For example, Reisman (2005) provides a taxonomy of TT with regard to its knowledge diffusion, utilization, management of technology, etc., rather than its economic implications.

The rest of the paper is organized as follows. Section 2 deals with the welfare implication of TT (who gains and who loses). Section 3 studies the effects of TT on factor prices (e.g., relative returns). Section 4 relates our results with the empirical findings in the literature. Section 5 concludes with a brief comment on a further research topic about the strategic implications of TT.

2 Technology Transfer and Welfare

In order to focus on the technology changes and their effects on trade, we consider a linear two-country-two-factor-two-product-two-different technology ($2 \times 2 \times 2 \times 2$) model. There are two countries, $i = 1, 2$. Each country i has a fixed amount of skilled labor L_s^i and a fixed amount of unskilled labor L_u^i, and produces two goods, clothing C^i and steel S^i. Each country i has a fixed-proportion production function for each good: For each unit of clothing it costs $a_{L_sC}^i$ units of skilled labor and $a_{L_uC}^i$ units of unskilled labor; for each unit of steel it costs $a^i_{L_sS}$ units of skilled labor and $a^i_{L_uS}$ units of unskilled labor. Assume that Country 1 has a representative agent with utility function $U^1(S^1, C^1) = \sqrt{S^1C^1}$ and Country 2 has a representative agent with utility function $U^2(S^2, C^2) = (S^2)^\alpha(C^2)^{1-\alpha)}$ (where $\alpha > 1/2$) implies that country 2 spends relatively more income on steel consumption).

Assume that before country 2 transfers a technology to country 1, there is no trade between the two countries. After or along with the transfer, trade takes place.

To be specific, assume that country 2 has a better technology in steel production in terms of a lower skilled labor cost, i.e., $a^2_{L_sS} < a^1_{L_sS}$. Assume that country 2 transfers this technology to country 1 free of charge. For concreteness, we assume that this transfer is achieved in the form that country 1 replaces its unit labor cost in the steel production, $a^1_{L_sS}$, by $a^2_{L_sS}$.

First, we show that TT can benefit both countries.

Theorem 1 *Technology transfer and trade always raise the welfare of the recipient country and it may also raise the welfare of the transferring country.*

Proof. Assume that there are full employment of resources in both countries. Before transfer Country 1 solves the following problem

$$\begin{aligned} \max U(S^1, C^1) &= \sqrt{S^1C^1} \\ a^1_{L_sS}S^1 + a^1_{L_sC}C^1 &= {L_s}^1 \\ a^1_{L_uS}S^1 + a^1_{L_uC}C^1 &= {L_u}^1 \end{aligned}$$

Assume that the optimal solution is at the intersection of the two resource constrains (see Figure 1, Country 1). Thus,

$$S^1 = \frac{\begin{vmatrix} {L_s}^1 & a^1_{L_sC} \\ {L_u}^1 & a^1_{L_uC} \end{vmatrix}}{\begin{vmatrix} a^1_{L_sS} & a^1_{L_sC} \\ a^1_{L_uS} & a^1_{L_uC} \end{vmatrix}}, C^1 = \frac{\begin{vmatrix} a^1_{L_sS} & {L_s}^1 \\ a^1_{L_uS} & {L_u}^1 \end{vmatrix}}{\begin{vmatrix} a^1_{L_sS} & a^1_{L_sC} \\ a^1_{L_uS} & a^1_{L_uC} \end{vmatrix}}.$$

And country 2 solves the following problem

$$\begin{aligned} \max U(S^2, C^2) &= (S^2)^\alpha(C^2)^{1-\alpha} \\ a^2_{L_sS}S^2 + a^2_{L_sC}C^2 &= {L_s}^2 \\ a^2_{L_uS}S^2 + a^2_{L_uC}C^2 &= {L_u}^2 \end{aligned}$$

Also assume that the optimal solution is at the intersection of the two resource constrains (see Figure 1, Country 2). Thus,

$$S^2 = \frac{\begin{vmatrix} {L_s}^2 & a^2_{L_sC} \\ {L_u}^2 & a^2_{L_uC} \end{vmatrix}}{\begin{vmatrix} a^2_{L_sS} & a^2_{L_sC} \\ a^2_{L_uS} & a^2_{L_uC} \end{vmatrix}}, C^2 = \frac{\begin{vmatrix} a^2_{L_sS} & {L_s}^2 \\ a^2_{L_uS} & {L_u}^2 \end{vmatrix}}{\begin{vmatrix} a^2_{L_sS} & a^2_{L_sC} \\ a^2_{L_uS} & a^2_{L_uC} \end{vmatrix}}.$$

After the transfer from country 2 to country 1, in country 1, $a^1_{L_sS}$ is replaced by a smaller $a^2_{L_sS}$. Apparently, this will lead to an outward steel-biased disproportional expansion of the PPF for country 1. This, in turn, will result in a different output if the two resources continue to be fully used.

$$S'^1 = \frac{\begin{vmatrix} {L_s}^1 & a^1_{L_sC} \\ {L_u}^1 & a^1_{L_uC} \end{vmatrix}}{\begin{vmatrix} a^2_{L_sS} & a^1_{L_sC} \\ a^1_{L_uS} & a^1_{L_uC} \end{vmatrix}}, C'^1 = \frac{\begin{vmatrix} a^2_{L_sS} & {L_s}^1 \\ a^1_{L_uS} & {L_u}^1 \end{vmatrix}}{\begin{vmatrix} a^2_{L_sS} & a^1_{L_sC} \\ a^1_{L_uS} & a^1_{L_uC} \end{vmatrix}}.$$

Apparently,

$$S'^1 > S^1, C'^1 < C^1.$$

But note that the total utility function is an increasing function of $a^2_{L_sS}$ as shown below.

$$U^1 = \sqrt{S'^1 C'^1} = \frac{1}{\begin{vmatrix} a^2_{L_sS} & a^1_{L_sC} \\ a^1_{L_uS} & a^1_{L_uC} \end{vmatrix}} \begin{vmatrix} {L_s}^1 & a^1_{L_sC} \\ {L_u}^1 & a^1_{L_uC} \end{vmatrix} \begin{vmatrix} a^2_{L_sS} & {L_s}^1 \\ a^1_{L_uS} & {L_u}^1 \end{vmatrix}.$$

$$\frac{\partial U^1}{\partial a^2_{L_sS}} > 0.$$

Thus, with a lower $a^2_{L_sS}$, the optimal solution will still be (C^1, S^1). However, by exporting S^1 and importing C^1 , country 1 can increase its utility to the level $\sqrt{S^{*1}C^{*1}}$, where $C^{*1} - C^1$ is the net import and $S^1 - S^{*1}$ is the net export (see Figure 1). The term of trade is shown as follows.

With no loss of generality, assume that clothing and steel industries are competitive in each country. Therefore, in each country prices equal marginal costs. For country 1, we have

$$\begin{aligned} P^1_C &= a^1_{L_sC} w^1_s + a^1_{L_uC} w^1_u, \\ P^1_S &= a^1_{L_sS} w^1_s + a^1_{L_uS} w^1_u, \end{aligned}$$

where P_C^1, P_S^1 are the prices of cloth and steel respectively, and w_s^1, w_u^1 are the real wages of the skilled labor and the unskilled labor, respectively.

Similarly, for country 2 we have

$$\begin{aligned} P_C^2 &= a_{L_sC}^2 w_s^2 + a_{L_uC}^2 w_u^2, \\ P_S^2 &= a_{L_sS}^2 w_s^2 + a_{L_uS}^2 w_u^2. \end{aligned}$$

Assume that the zero profit line for cloth is flatter than for steel in both countries (see Figure 1). Then, for country 1, we have

$$\frac{P_C^1}{a_{L_uC}^1} \leq \frac{P_S^1}{a_{L_uS}^1}, \frac{P_C^1}{a_{L_sC}^1} \geq \frac{P_S^1}{a_{L_sS}^1},$$

and thus

$$\frac{a_{L_sC}^1}{a_{L_sS}^1} \leq \frac{P_C^1}{P_S^1} \leq \frac{a_{L_uC}^1}{a_{L_uS}^1}.$$

Similarly, for country 2, we have

$$\frac{P_C^2}{a_{L_uC}^2} \leq \frac{P_S^2}{a_{L_uS}^2}, \frac{P_C^2}{a_{L_sC}^2} \geq \frac{P_S^2}{a_{L_sS}^2},$$

and thus

$$\frac{a_{L_sC}^2}{a_{L_sS}^2} \leq \frac{P_C^2}{P_S^2} \leq \frac{a_{L_uC}^2}{a_{L_uS}^2}.$$

Without loss of generality, assume that the relative price of cloth in country 2 is less than or equal to that in country 1. Then, after trade opens and the transfer of technology takes place, prices will be equalized for each good between the two countries. Thus, the term of trade improves for Country 2. We assume that the equilibrium price ratio P_C^*/P_S^* satisfies the following condition.

$$\frac{P_C^2}{P_S^2} \leq \frac{P_C^*}{P_S^*} \leq \frac{P_C^1}{P_S^1}.$$

For country 1, the budget line (or the isovalue line) that passes through the initial point (S^1, C^1) lies below the new line that passes through (S'^1, C'^1). That is,

$$P_C^* C + P_S^* S = P_C^* C'^1 + P_S^* S'^1 > P_C^* C^1 + P_S^* S^1.$$

Country 1 can produce at the point (S'^1, C'^1) but trade along the new higher line

$$P_C^* C + P_S^* S = P_C^* C'^1 + P_S^* S'^1.$$

This would increase country 1's welfare.

Now for country 2, its welfare can also be increased through trade as the term of trade improves. As shown in Figure 1, country 1 exports steel but imports cloth, country 2 imports steel but exports cloth. This proves the theorem.

Insert Figure 1 here.

3 Technology Transfer and Factor Prices

Now we turn to the effects of TT on factor prices. The following result is reminiscent of the Stolper-Samuelson theorem. But here we emphasize the change in technology and its effects on factor prices. The induced changes in product prices through trade will have effects on factor prices, but for the technology receiving country the effects of the products prices changes on factor prices are dominated by the effects from the technology change. However, for the technology transferring country, the Stopler-Samuelson theorem applies, i.e., the changes in factor prices come from the induced changes in product prices.

First, recall that perfect competition in each industry in each country implies

$$a_{L_sC}^1 w_s^1 + a_{L_uC}^1 w_u^1 = a_{L_sC}^2 w_s^2 + a_{L_uC}^2 w_u^2 = P_C^* \tag{1}$$

$$a_{L_sS}^1 w_s^1 + a_{L_uS}^1 w_u^1 = a_{L_sS}^2 w_s^2 + a_{L_uS}^2 w_u^2 = P_S^* \tag{2}$$

Now we assume that the zero profit line for cloth is strictly flatter than that for steel (Figure 2). Thus, we have

$$\frac{P_C^*}{a_{L_uC}^1} < \frac{P_S^*}{a_{L_uS}^1}, \frac{P_C^*}{a_{L_sC}^1} > \frac{P_S^*}{a_{L_sS}^1}, \tag{3}$$

and

$$\frac{a_{L_sC}^1}{a_{L_uC}^1} < \frac{a_{L_sS}^1}{a_{L_uS}^1},$$

that is, in country 1, steel is relatively skilled labor intensive than cloth. We assume that country 2 has more advanced technologies both in the production of cloth and the production of steel in terms of labor cost. We will study the effects of TT on factor prices in both countries. But first, we assume that

$$a^1_{L_sC} > a^2_{L_sC}. \tag{4}$$

and

$$a^1_{L_sS} > a^2_{L_sS}. \tag{5}$$

respectively. Assume also that each industry is competitive. Assume also that after the technology transfer the two countries open trade but product prices still satisfy the inequality conditions in (3).

Insert Figure 2 here.

We have the following result.

Theorem 2 *For the technology receiving country, technology transfer that leads to a more efficient use of a factor (skilled labor) which is less intensively used in the production of the good (e.g., cloth) would decrease that factor's price but increase the other factor (unskilled labor) price. On the other hand, if the technology transfer leads to a more efficient use of the factor (skilled labor) that is more intensively used in the production of the good (e.g, steel), then this transfer will increase the factor price while decrease the other factor (unskilled labor) price. For the technology transferring country, the term of trade improves (importing price of steel decreases while the exporting price of cloth increases). These changes in turn, increase the factor price of skilled labor but decreases the factor price of the unskilled labor in the transferring country.*

Proof. The transfer of technology from country 2 to country 1 in the cloth industry to increase the skilled labor efficiency will make country 1 to adjust its factor prices by the following equilibrium conditions:

$$\begin{aligned} P^*_C &= a^2_{L_sC} w^1_s + a^1_{L_uC} w^1_u \\ P^*_S &= a^1_{L_sS} w^1_s + a^1_{L_uS} w^1_u \end{aligned}$$

In matrix form, we have

$$\begin{pmatrix} P^*_C \\ P^*_S \end{pmatrix} = \begin{pmatrix} a^2_{L_sC} & a^1_{L_uC} \\ a^1_{L_sS} & a^1_{L_uS} \end{pmatrix} \begin{pmatrix} w^1_s \\ w^1_u \end{pmatrix} = A \begin{pmatrix} w^1_s \\ w^1_u \end{pmatrix}$$

we easily find that

$$A^{-1} = \frac{1}{a^2_{L_sC}a^1_{L_uS} - a^1_{L_sS}a^1_{L_uC}} \begin{pmatrix} a^1_{L_uS} & -a^1_{L_uC} \\ -a^1_{L_sS} & a^2_{L_sC} \end{pmatrix}.$$

Thus,

$$w^1_s = \frac{1}{a^2_{L_sC}a^1_{L_uS} - a^1_{L_sS}a^1_{L_uC}}(a^1_{L_uS}, -a^1_{L_uC}) \begin{pmatrix} P^*_C \\ P^*_S \end{pmatrix},$$

$$w^1_u = \frac{1}{a^2_{L_sC}a^1_{L_uS} - a^1_{L_sS}a^1_{L_uC}}(-a^1_{L_sS}, a^2_{L_sC}) \begin{pmatrix} P^*_C \\ P^*_S \end{pmatrix}.$$

And, we have

$$\frac{\partial w^1_s}{\partial a^2_{L_sC}} = \frac{a^1_{L_uS}a^1_{L_uS}a^1_{L_uC}[\frac{P^*_S}{a^1_{L_uS}} - \frac{P^*_C}{a^1_{L_uC}}]}{(a^2_{L_sC}a^1_{L_uS} - a^1_{L_sS}a^1_{L_uC})^2} > 0,$$

which implies

$$a^2_{L_sC} \downarrow \Rightarrow w^1_s \downarrow .$$

Similarly,

$$\frac{\partial w^1_u}{\partial a^2_{L_sC}} = \frac{a^1_{L_uS}a^1_{L_sS}a^1_{L_uC}[\frac{P^*_C}{a^1_{L_uC}} - \frac{P^*_S}{a^1_{L_uS}}]}{(a^2_{L_sC}a^1_{L_uS} - a^1_{L_sS}a^1_{L_uC})^2} < 0,$$

which implies

$$a^2_{L_sC} \downarrow \Rightarrow w^1_u \uparrow .$$

This proves the first part of the theorem.

On the other hand, if country 2 transfers a technology that reduces the skilled labor cost in the production of steel, i.e.,

$$a^1_{L_sS} < a^2_{L_sS},$$

then country 1 will adjust its factor prices by the following equilibrium conditions:

$$\begin{aligned} P^*_C &= a^1_{L_sC}w^1_s + a^1_{L_uC}w^1_u \\ P^*_S &= a^2_{L_sS}w^1_s + a^1_{L_uS}w^1_u \end{aligned}$$

In matrix form, we have

$$\begin{pmatrix} P_C^* \\ P_S^* \end{pmatrix} = \begin{pmatrix} a^1_{L_sC} & a^1_{L_uC} \\ a^2_{L_sS} & a^1_{L_uS} \end{pmatrix} \begin{pmatrix} w^1_s \\ w^1_u \end{pmatrix} = A \begin{pmatrix} w^1_s \\ w^1_u \end{pmatrix}$$

we find that

$$A^{-1} = \frac{1}{a^1_{L_sC}a^1_{L_uS} - a^2_{L_sS}a^1_{L_uC}} \begin{pmatrix} a^1_{L_uS} & -a^1_{L_uC} \\ -a^2_{L_sS} & a^1_{L_sC} \end{pmatrix}.$$

Thus,

$$w^1_s = \frac{1}{a^1_{L_sC}a^1_{L_uS} - a^2_{L_sS}a^1_{L_uC}} (a^1_{L_uS}, -a^1_{L_uC}) \begin{pmatrix} P_C^* \\ P_S^* \end{pmatrix},$$

$$w^1_u = \frac{1}{a^1_{L_sC}a^1_{L_uS} - a^2_{L_sS}a^1_{L_uC}} (-a^2_{L_sS}, a^1_{L_sC}) \begin{pmatrix} P_C^* \\ P_S^* \end{pmatrix}.$$

And, we have

$$\frac{\partial w^1_s}{\partial a^2_{L_sS}} = \frac{a^1_{L_uC}a^1_{L_uS}a^1_{L_uC}[\frac{P_C^*}{a^1_{L_uC}} - \frac{P_S^*}{a^1_{L_uS}}]}{(a^1_{L_sC}a^1_{L_uS} - a^2_{L_sS}a^1_{L_uC})^2} < 0,$$

which implies

$$a^2_{L_sS} \downarrow \Rightarrow w^1_s \uparrow .$$

Similarly,

$$\frac{\partial w^1_u}{\partial a^2_{L_sS}} = \frac{a^1_{L_uC}a^1_{L_sC}a^1_{L_uS}[\frac{P_S^*}{a^1_{L_uS}} - \frac{P_C^*}{a^1_{L_uC}}]}{(a^1_{L_sC}a^1_{L_uS} - a^2_{L_sS}a^1_{L_uC})^2} > 0,$$

which implies

$$a^2_{L_sS} \downarrow \Rightarrow w^1_u \downarrow .$$

This proves the case for country 1, the technology receiving country.

Now we prove the case for country 2, the technology transferring country.

Consider now the perfect competition condition in country 2:

$$a^2_{L_sC}w^2_s + a^2_{L_uC}w^2_u = P_C^* \tag{6}$$

$$a^2_{L_sS}w^2_s + a^2_{L_uS}w^2_u = P_S^* \tag{7}$$

In matrix form, we have

$$\begin{pmatrix} P_C^* \\ P_S^* \end{pmatrix} = \begin{pmatrix} a_{L_sC}^2 & a_{L_uC}^2 \\ a_{L_sS}^2 & a_{L_uS}^2 \end{pmatrix} \begin{pmatrix} w_s^2 \\ w_u^2 \end{pmatrix} = A \begin{pmatrix} w_s^2 \\ w_u^2 \end{pmatrix}$$

we find that

$$A^{-1} = \frac{1}{a_{L_sC}^2 a_{L_uS}^2 - a_{L_sS}^2 a_{L_uC}^2} \begin{pmatrix} a_{L_uS}^2 & -a_{L_uC}^2 \\ -a_{L_sS}^2 & a_{L_sC}^2 \end{pmatrix}.$$

Thus,

$$w_s^2 = \frac{1}{a_{L_sC}^2 a_{L_uS}^2 - a_{L_sS}^2 a_{L_uC}^2} (a_{L_uS}^2, -a_{L_uC}^2) \begin{pmatrix} P_C^* \\ P_S^* \end{pmatrix},$$

$$w_u^2 = \frac{1}{a_{L_sC}^2 a_{L_uS}^2 - a_{L_sS}^2 a_{L_uC}^2} (-a_{L_sS}^2, a_{L_sC}^2) \begin{pmatrix} P_C^* \\ P_S^* \end{pmatrix}.$$

Thus,

$$\frac{\partial w_s^2}{\partial P_C^*} = \frac{a_{L_uS}^2}{a_{L_sC}^2 a_{L_uS}^2 - a_{L_sS}^2 a_{L_uC}^2},$$

$$\frac{\partial w_s^2}{\partial P_S^*} = \frac{-a_{L_uC}^2}{a_{L_sC}^2 a_{L_uS}^2 - a_{L_sS}^2 a_{L_uC}^2},$$

and similarly

$$\frac{\partial w_u^2}{\partial P_C^*} = \frac{-a_{L_sS}^2}{a_{L_sC}^2 a_{L_uS}^2 - a_{L_sS}^2 a_{L_uC}^2},$$

$$\frac{\partial w_u^2}{\partial P_S^*} = \frac{a_{L_sC}^2}{a_{L_sC}^2 a_{L_uS}^2 - a_{L_sS}^2 a_{L_uC}^2}.$$

Therefore,

$$a_{L_sS}^2 \downarrow \Rightarrow P*_S \downarrow, P*_C \uparrow \Rightarrow w_s^2 \uparrow, w_u^2 \downarrow.$$

This proves the theorem.

4 Technology Changes and Wage Inequality

We have shown in Theorem 2 that TT can change the relative factor prices in the recipient country. In fact, we can use Theorem 2 to explain the effects of technology change (e.g., computerization in business and industries) on the relative wages between skilled workers and unskilled workers within a given country.

As pointed out by Slaught (1999), rising wage inequality has been experienced in the US and many other countries in the last 40 years. Many researchers have tried to explain the rising inequality using to two different approaches: the 'labor' approach and the 'trade' approach. In the 'labor' approach, changes in wage are linked with the changes in labor supply, labor demand, and labor market institutions. In the 'trade' approach, it is assumed that there are many sectors in the economy and the standard Heckscher-Ohlin model is used. In the latter approach, it has been shown empirically that wages tend to rise for factors employed intensively in sectors enjoying relatively large technology gains. It has also been shown in a two-good model with fixed product prices that any innovation in the unskilled-intensive sector unambiguously lowers the skill premium (Slughter 1999, page 623).

Theorem 2 can provide a simple explanation for the fall and rise in the US skill premium in the 1970s and the 1980s respectively. In the 1970s, the skill premium fell because technology progress concentrated in the unskilled-intensive sector. As shown in Theorem 2, as technology improves, the skilled labor which is less intensively used in the production of the good (e.g., clothing sector) would experience a decrease in its factor's price but the other factor (unskilled labor) will experience an increase in its factor price, thus the skill premium fells. On the other hand, technological progress concentrated in the skill-intensive (e.g., steel or other high technology industries) sectors would raise the skill premium because a more efficient use of the factor (skilled labor) that is more intensively used in the production of the good (e.g, steel) will increase the skilled labor factor price while decrease the other factor price (unskilled labor), thus the skill premium rises.

Theorem 2 can also explain the wage inequality resulted from FDI in the developing countries. Indeed, Feenstra and Hanson (1997) have already considered that multinational enterprises provide TT via FDI. They have studied the increase in relative wages for skilled workers in Mexico during the 1980s and shown that rising wage inequality in Mexico is related to foreign capital inflows. They show that the growth in FDI is positively correlated with the relative demand for skilled labor and that growth in FDI can account for over 50 percent of the increase in the skilled labor wage share. Wu (2000) does a similar study for China and shows that FDI increases the relative wage of skilled labor to unskilled labor.

According to the Heckscher-Ohlin theory, changes in factor prices are linked to changes in product prices (Stolper-Samuelson theorem). Slaughter (2000) surveys a number of recent economic studies of product prices, factor intensities, and wages. He observes that there is a lack of change in the relative prices of traded goods and the rising skill intensity of production are not consistent with the prediction by the Stolper-Samuelson theorem. This indicates that price changes in international trade are not the dominant cause of the rising wage inequality. Many other studies have obtained similar conclusion (see the survey by Slaughter, 2000)

Our explanation that the technological progress can cause wage inequality to rise between the skilled labor and the unskilled labor is different from the traditional so-called 'derived demand' explanation. In the latter, it is argued that, first, technological progress has been faster in industries that are more intensive in skilled labor. As the cost and prices of some skill-intensive products decline, the demand for the products increases. As demand shifts toward skill-intensive products and their production increases, the demand for skilled labor expands, increasing the relative wage of skilled labor. However, this explanation may run into a secondary demand effect (negative) that is generated from the effect of technological progress. As the relative wage of the skilled labor increases, industries are induced to use less of the skilled labor. This, in turn, induces an increased demand for the less-skilled labor and thus drives up the relative wage of the less-skilled labor. This is the so-called "factor-ratio paradox" (see Pugel, page 73, 2004). Our explanation avoids this paradox.

5 Concluding Remarks

We have shown that TT from a country with an advanced technology (e.g., a developed country) to a country with the less advanced technology (e.g., a developing country) could possibly benefit both countries. We also show that the transfer of technology could change the relative wages (factor prices) in the recipient country and sometimes may cause an increase in wage inequality. The model allows us to focus on technology changes and their effects on trade and factor prices.

We should point out that our analysis of TT is a short-run analysis. One of the main result, that it is always beneficial for a country to receive a better and advanced technology from another country, may not be true in the long-run. It is indeed cost-effective for a less developed country to receive an advanced technology from a developed country as it might be unrealistic for the country to develop its own technology from scratch. However, from the long-run point of view, this TT may come with costs (e.g., a continued reliance on foreign technology). These costs not only include, for example, license costs, intellectual property rights, purchasing cost of the technology, etc., but also the potential long-run costs to the recipient country that are associated with the induced disincentive of its own R&D investments.

In which stage a developing country should reconsider its strategy on technology imports is an important issue. This aspect of TT has not been studied in the literature and it seems worthwhile to investigate.

References

[1] Beladi, H., Jones, R. W., Marjit, S. (1997). Technology for Sale. Pacific Economic review 2(3), 187-96.

[2] Cheng, L. K., Qiu, L. D., Tan, Guofu. (1999). Technology Transfer, Foreign Direct Investment and International Trade. Working Paper

[3] Ekholm, K. (1995). Multinational Production and Trade in Technoloical Knowledge. Lund Economic Studies 58, University of Lund, Sweden.

[4] Feenstra, R. C., Hanson, G. H. (1996). "Foreign investment, Outsourcing and Relative Wages, " in R. C. Feestra, G. M. Grossman and D. A. Irwin, eds., The Political Economy of Trade Policy: papers in Honor of Jagdish Bhagwati, MIT Press.

[5] Feenstra, R. C., Hanson, G. H. (1997). Foreign direct investment and relative wages: Evidence from Mexico's maquiladoras. Journal of International economics 42, 371-93.

[6] Feenstra, R. C., Hanson, G. H. (1997). Productivity Measurement and the Impact of Trade and technology on Wages: Estimates for the US, 1972-1990. NBER Working Paper No. 6052.

[7] Jones, R. W. (1979). Technical Progress and Real Incomes in a Ricardian Trade Model, in R. W. Jones, International Trade: Essays in Thoery, North-Holland, Amsterdam.

[8] Jones, R. W. (1985). Income Effects and Paradoxes in the Theory of International Trade. Economic Journal 95, 330-44.

[9] Markusen, J. R. (1984). Multinationals, Multi-plant Economies, and the Gains from Trade. Journal of International Economics 16, 205-26.

[10] Pugel, T. A. (2004). International Economics. 12th ed. McGraw-Hill.

[11] Reisman, A. (2005). Transfer of Technologies: A cross-disciplinary taxonomy. Omega 33, 189-202.

[12] Ruffin, R. J., Jones, R. W. (2007). International Technology Transfer: Who Gains and Who Loses? Review of International Economics 15(2), 209-22.

[13] Ruffin, R. J., Jones, R. W. (2005). The Technology Transfer Paradox, Working paper.

[14] Quinn, J. B. (1969). Technology Transfer by Multinational Companies. Harvard Business Review, November-December, 147-161.

[15] Slaughter, M. J. (1999). Globalization and Wages: A Tale of Two Perspective. World Economy 22 (5), 609-29.

[16] Slaughter, M. J. (2000). What Are the Results of Product-Price Studies and What Can We Learn from Their Differences? In Impact of International Trade and Wages, ed. R. C. Feenstra, Chicago: University of Chicago Press, 129-70.

[17] Xiaodong Wu (2000). Foreign Direct Investment, Intellectual Property Rights and Wage Inequality in China. Working Paper, University of North Carolina at Chapel Hill.