

# Is FTA/EPA effective for a developing country to attract FDI? : simulation analysis based on an extended knowledge-capital model

著者	Oyamada Kazuhiko, Uchida Yoko
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## IDE DISCUSSION PAPER No. 517

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Kazuhiko OYAMADA  
Yoko UCHIDA

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To prepare an answer to the question of how a developing country can attract FDI, this paper explored the factors and policies that may help bring FDI into a developing country by utilizing an extended version of the knowledge-capital model. With a special focus on the effects of FTAs/EPAs between market countries and developing countries, simulations with the model revealed the following: (1) Although FTA/EPA generally ends to increase FDI to a developing country, the possibility of improving welfare through increased demand for skilled and unskilled labor becomes higher as the size of the country declines; (2) Because the additional implementation of cost-saving policies to reduce firm-type/trade-link specific fixed costs ends to depreciate the price of skilled labor by saving its input, a developing country, which is extremely scarce in skilled labor, is better off avoiding the additional option; (3) If a country hopes to enjoy larger welfare gains with EPA, efforts to increase skilled labor in the country, such as investing in education, may be beneficial.

**Keywords:** foreign direct investment; multinational enterprise; export platform; free trade agreement; economic partnership agreement

**JEL classification:** F11; F12; F15; F23

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**INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO**  
**3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI**  
**CHIBA 261-8545, JAPAN**

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# **Is FTA/EPA Effective for a Developing Country to Attract FDI? Simulation Analysis Based on an Extended Knowledge-Capital Model\***

Kazuhiko OYAMADA<sup>†</sup>

Yoko UCHIDA<sup>‡</sup>

March 12, 2015

## **Abstract**

To prepare an answer to the question of how a developing country can attract FDI, this paper explored the factors and policies that may help bring FDI into a developing country by utilizing an extended version of the knowledge-capital model. With a special focus on the effects of FTAs/EPAs between market countries and developing countries, simulations with the model revealed the following: (1) Although FTA/EPA generally ends to increase FDI to a developing country, the possibility of improving welfare through increased demand for skilled and unskilled labor becomes higher as the size of the country declines; (2) Because the additional implementation of cost-saving policies to reduce firm-type/trade-link specific fixed costs ends to depreciate the price of skilled labor by saving its input, a developing country, which is extremely scarce in skilled labor, is better off avoiding the additional option; (3) If a country hopes to enjoy larger welfare gains with EPA, efforts to increase skilled labor in the country, such as investing in education, may be beneficial.

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<sup>†</sup> Institute of Developing Economies, Japan External Trade Organization (IDE-JETRO), 3-2-2 Wakaba, Mihama-Ku, Chiba-Shi, Chiba 261-8545, Japan (kazuhiko\_oyamada@ide.go.jp)

<sup>‡</sup> IDE-JETRO (yoko\_uchida@ide.go.jp)

## 1. Introduction

How can a developing country attract foreign direct investment (FDI)? This question has long been the subject of debate among policy-makers in developing economies who regard FDI as an important catalyst for economic growth. As the global economy has become increasingly interdependent, multinational enterprises (MNEs) form multilateral production networks, where production processes are subdivided into several stages and some developing countries have successfully participated in certain parts of these networks. The purpose of this paper is to explore the factors and policies that may help to bring FDI into a developing country.

While research on the activities of MNEs has been conducted widely since the late 1980s, a limited number of studies has comprehensively handled every operational pattern of MNEs in one model. Especially, the export-platform is not much discussed in the theoretical studies, even though its importance has been revealed by the empirical side. Because a low-cost developing country may play an important role as an export-platform, an analytical model for this study must include this type in addition to the typical horizontal- and vertical-type MNEs.

One of the most sophisticated studies that considers typical types of MNEs including export-platforms in the same analytical framework was presented by Ekholm, Forslid, and Markusen (2007). Using a numerical simulation model, in which two market countries and one exogenously given developing country are considered, they explored the conditions under four types of firm strategy while gradually changing two types of costs, one for trading components and the other for assembling components. However, their model has only one factor of production, and the non-market country is just assumed to set exogenous factor pricing in a partial equilibrium framework. Another work that nests every type of MNE in one model is presented by Ito (2012). Extending the two-region, four-country (two countries in each region) model developed by Navaretti and Venables (2004) to include export-platform, he showed that a reduction in trade costs, either inter-regional or intra-regional, induces firms to choose export-platform rather than other types. To enable the theoretical model to yield testable hypotheses for empirical testing, he incorporated only trade costs abstracting production costs away.

A good candidate for the base of an analytical model that includes both trade and production costs in a general equilibrium setting is the knowledge-capital model developed by Markusen (1997) and further extended by Zhang and Markusen (1999). Although export-platform is not taken into account, the computational model is able to verify effects

of changes in firm-type on factor prices in the countries where the MNEs are active. As employment and labor wages in the host country are important factors MNEs use to decide on a production strategy, this feature based on the general equilibrium nature of the knowledge-capital model is essential for our study. Thus, we utilized an extended version of the model for this study.

The remainder of this paper is organized as follows. Section 2 illustrates the structure and main assumptions of the analytical model. Section 3 explains how the model is parameterized as a numerical model. In Section 4, we perform simulations and report on the results that reveal conditions for which each type of firms would be active in a given economic environment with a special focus on the effects of trade liberalization and optional cost-saving policies. Finally, Section 5 presents the conclusions of this paper.

## **2. The Extended Knowledge-Capital Model**

The model used in this study is a simple extension of the knowledge-capital model that was used as the workhorse in Markusen (2002), including national enterprises (NEs), horizontal MNEs (HMNEs), vertical MNEs (VMNEs), and export-platform MNEs (EMNEs). The model is also extended to include two developing countries, in which the final assembly process of multinational production may take place while the finished products are not sold locally but exported, which is in addition to the original assumption of two developed countries in which MNEs are established and there are markets for the commodity produced by those MNEs.

An important point here is that we do not limit the volumes of those developing countries, which always stay small in terms of factor endowments. Because the knowledge-capital model is a general equilibrium model, branching out and setting up subsidiaries by MNEs in a developing country affects the local factor prices. If the host country is relatively small, factor prices appreciate more than they would in a relatively large country. This may substantially frustrate the incentive of the MNE to stay in the country and trigger it to find another place where cheaper production factors are available.

With this model, we investigate which production pattern is adopted by firms established in two countries out of four to sell Product in both home and foreign (target) markets under certain economic circumstances.

### **2.1 Environment**

There are four countries  $A$ ,  $B$ ,  $C$ , and  $D$ , indexed as  $r$ .  $A$  and  $B$  are assumed to be countries in which MNEs are established and there are markets for the commodity produced by those MNEs. We index these countries  $i$  or  $j$  as a subset of  $r$ .  $C$  and  $D$  are countries in which the final assembly process of multinational productions may take place while the finished products are not sold locally but exported. The index of these countries is  $w$ , another subset of  $r$ .

There are three types of goods,  $X$ ,  $Y$ , and  $Z$ . The intermediate good (a component)  $X$  is used to produce the final product  $Y$  by the MNE. This sector exhibits increasing returns to scale (IRTS) so that the market is assumed to be imperfectly competitive.  $X$  is produced only in the home of the MNE, country  $i$ , and is sent to country  $r$  where the final assembly process takes place. The finished product  $Y$  is sold on the target market  $j$ . Note that all MNEs in each production type, national  $N$ , horizontal  $H$ , export-platform  $E$ , and vertical  $V$ , indexed as  $q$ , share identical technologies and productivities. On the other hand,  $Z$  is a regular product based on a constant-returns-to-scale (CRTS) technology so that the market is perfectly competitive.  $Z$  is produced in every country  $r$ , and is sold on the international market as a perfect substitute.

Production factors are of two types,  $K$  and  $L$ , which are immobile among national boundaries. Although we mainly regard  $K$  as skilled labor (human capital) in this study, it can be further extended to include the status of institutions (rules and regulations) and/or the business environment.  $L$  is unskilled labor. The national endowments of these factors are set exogenously in the model. In the experimental simulations, we change the relative factor endowments for either the developed- or developing-country groups given absolute levels of total endowments for the groups.

In the IRTS sector, two types of fixed cost,  $F$  and  $G$ , are required to start operating a firm. Whereas  $G$ , measured in units of unskilled labor  $L$ , is needed to set up an assembly plant in country  $r$  (country specific),  $F$ , measured in units of skilled labor  $K$ , is required to establish a firm and its local subsidiary in a foreign country (firm-type/trade-link specific).

There are also trade costs for international transport of  $X$  and  $Y$ , which are specific to each trade link. We assume that unskilled labor  $L$  in the exporting country is used for this. On the other hand, it is assumed for simplicity that shipping  $Z$  does not generate any cost.

## 2.2 Type-Y Good Producer

There are two groups of firms producing  $Y$ , one is established and headquartered in country  $A$  and the other in  $B$  (country  $i$ ). The markets for  $Y$  are limited to countries  $A$  and  $B$  (country  $j$ ). Good  $Y$  is produced in two stages with IRTS technology by imperfectly competitive firms. In the first stage, each firm produces its components (intermediate good)  $X$  only in its home country using skilled labor  $K$ . In the second stage, a firm may send its components to a foreign subsidiary and finalize the production of  $Y$  there, assembling components  $X$  using locally hired unskilled labor  $L$ . This assembly process can take place in any country  $r$ . If the assembly is taking place in a developing country  $w$ , all of the final products are exported to one or both of the developed countries  $j$ . If it is performed in the home country  $i$ , the products are sold domestically or exported to a foreign market  $j$ . If it takes place in a foreign market country  $i$ , the products are only sold locally. In addition, if a firm has only one plant in a market country  $i$ , it must be located in the home country.

There are both firm-level and plant-level scale economies. By free entry and exit of firms in each operational pattern, a production regime, which refers to a combination of firm types in an equilibrium, is determined. Following Ekholm, Forslid, and Markusen (2007), regimes will be denoted by suffices with letters, the first letter referring to a firm's home country  $i$ , the second one referring to the destination market  $j$ , and the third one referring to the location of its assembly plant ( $i$  or  $w$ ). When it is possible to omit some of those letters without creating any confusion, the length of the suffix becomes shorter. The regimes are categorized into four types,  $N$ ,  $H$ ,  $E$ , and  $V$ , which express the production pattern of a firm. The four production-types are defined as follows.

**Type-N:** NEs that maintain a single plant with headquarters in country  $i$ . This type of firms produces both components  $X$  and final products  $Y$  in country  $i$ . A fraction of the products  $Y$  may or may not be exported to country  $j$ .

**Type-H:** HMNEs that maintain plants in both market countries, with headquarters in country  $i$ . This type of firms produces components  $X$  in country  $i$ , some of which are shipped to an assembly plant in country  $j$ . The final products  $Y$  are produced in both market countries. No fraction of product  $Y$  may be exported.

**Type-E:** EMNEs that maintain a plant in one of the developing countries  $w$ , in addition to a plant and headquarters in home country  $i$ . This type of firms produces components  $X$  in



country  $i$ , some of which are shipped to an assembly plant in country  $w$ . All of the final products  $Y$  produced in country  $w$  are exported to the foreign market in country  $j$ , while the ones produced in the home country are sold domestically.

**Type-V:** VMNEs that maintain a single plant in one of the developing countries  $w$ , with headquarters in country  $i$ . This type of firm produces components  $X$  in country  $i$ , which are then shipped to the assembly plant in country  $w$ . All of the final products  $Y$  are exported to both of the markets in developed countries  $j$ .

Figure 1 shows schematic images of these four types of production patterns. In each pattern, the headquarters of the firm is located in the country placed on the left-hand side of the image.

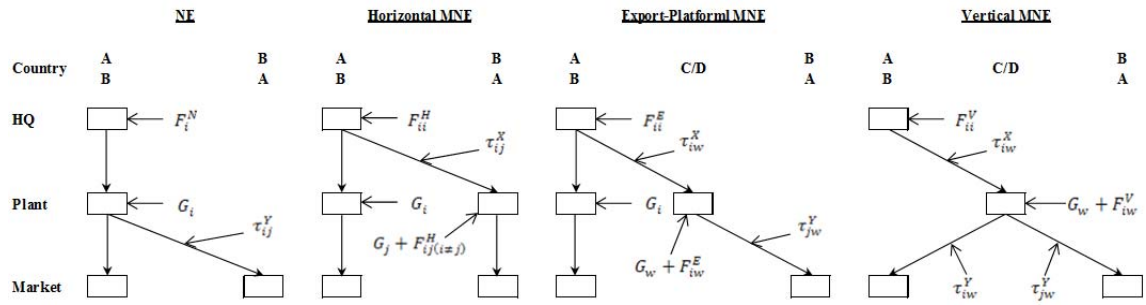


Figure 1: Four Types of Production Patterns

## 2.2.1 Type-N Firm Established in Country $i$

A type-N firm produces three types of products: components  $X_i^N$ ; final products for the domestic market  $Y_{ij}^N (i=j)$ ; and final products for the foreign market  $Y_{ij}^N (i \neq j)$ . The skilled labor requirements to produce one unit of a component in home country  $i$  can be expressed as:

$$K_i^N = \theta^K X_i^N + F_i^N, \quad (1)$$

where

$K_i^N$  is the skilled labor input hired in country  $i$ ;

$X_i^N$  is the quantity of components produced;

$F_i^N$  is the fixed cost to establish a NE in country  $i$ ; and

$\theta^K$  is the unit input requirement for skilled labor.

Similarly, the requirements for both unskilled labor and components to produce one unit of final product in home country  $i$  can be expressed as:

$$L_i^N = \theta^L \sum_j Y_{ij}^N + (\tau_{ij}^Y Y_{ij}^N)_{(i \neq j)} + G_i; \quad (2)$$

and

$$X_i^N = \theta^X \sum_j Y_{ij}^N, \quad (3)$$

where

$L_i^N$  is the unskilled labor hired in country  $i$ ;

$Y_{ij}^N$  is the quantity of final products;

$G_i$  is the fixed cost to set up an assembly plant in country  $i$ ;

$\theta^L$  is the unit input requirement for unskilled labor;

$\theta^X$  is the unit input requirement for components; and

$\tau_{ij}^Y$  is the rate of trade cost for the international shipping of final products.

Then, the cost function for a type-N firm is given by:

$$\begin{aligned} & p_i^K K_i^N + p_i^L L_i^N \\ &= \{(p_i^K \theta^K \theta^X + p_i^L \theta^L) Y_{ij}^N\}_{(i=j)} + [\{p_i^K \theta^K \theta^X + p_i^L (\theta^L + \tau_{ij}^Y) Y_{ij}^N\}]_{(i \neq j)} \\ & \quad + (p_i^K F_i^N + p_i^L G_i), \end{aligned} \quad (4)$$

where

$p_i^K$  is the price of skilled labor; and

$p_i^L$  is the price of unskilled labor.

The first term on the right-hand side of Equation (4) corresponds to the variable cost with respect to  $Y_{ij}^N$  ( $i=j$ ). Similarly, the second term corresponds to the one with respect to  $Y_{ij}^N$  ( $i \neq j$ ). The last term corresponds to the total fixed cost.

## 2.2.2 Type-H Firm Established in Country $i$

A type-H firm produces four types of products: components  $X_{ij}^H$  ( $i=j$ ); components  $X_{ij}^H$  ( $i \neq j$ ); final products for the domestic market  $Y_{ij}^H$  ( $i=j$ ); and final products for the foreign market  $Y_{ij}^H$  ( $i \neq j$ ). The skilled labor requirements to produce one unit of components in the home country  $i$  can be expressed as:

$$K_{ii}^H = \theta^K \sum_j X_{ij}^H + F_{ii}^H, \quad (5)$$

where

$K_{ii}^H$  is the skilled labor input hired in country  $i$ ;

$X_{ij}^H$  is the quantity of components produced; and

$F_{ii}^H$  is the fixed cost to establish a HMNE in country  $i$ .

To ship components  $X_{ij(i \neq j)}^H$  from country  $i$  to destination  $j$ , the following amount of unskilled labor must be hired in country  $i$ :

$$L_{ii}^{HT} = (\tau_{ij}^X X_{ij}^H)_{(i \neq j)}, \quad (6)$$

where

$L_{ii}^{HT}$  is the unskilled labor hired for international shipping; and

$\tau_{ij(i \neq j)}^X$  is the rate of trade cost for the international shipping of components.

Next, the requirements for both unskilled labor and components to produce one unit of final products in home country  $i$  can be expressed as:

$$L_{ii}^{HP} = \theta^L Y_{ii}^H + G_i; \quad (7)$$

and

$$X_{ii}^H = \theta^X Y_{ii}^H, \quad (8)$$

where

$L_{ii}^{HP}$  is the unskilled labor input hired in country  $i$ ; and

$Y_{ii}^H$  is the quantity of final products assembled in country  $i$ .

Similarly, the requirements for both unskilled labor and components to produce one unit of final products in foreign country  $j$  are:

$$L_{ij(i \neq j)}^{HP} = \theta^L Y_{ij(i \neq j)}^H + G_j; \quad (9)$$

and

$$X_{ij(i \neq j)}^H = \theta^X Y_{ij(i \neq j)}^H, \quad (10)$$

where

$L_{ij}^{HP}$  is the unskilled labor input hired in country  $j$ ;

$Y_{ij}^H$  is the quantity of final products assembled in country  $j$ ; and

$G_j$  is the fixed cost to set up an assembly plant in country  $j$ .

At the local subsidiary in foreign country  $j$ , skilled labor is needed to train unskilled labor how to handle the intermediate:

$$K_{ij(i \neq j)}^H = F_{ij(i \neq j)}^H, \quad (11)$$

where

$K_{ij(i \neq j)}^H$  is the skilled labor input hired in country  $j$ ; and

$F_{ij(i \neq j)}^H$  is the fixed cost to set up an assembly plant in country  $i$ .

Then, the cost function for a type-H firm is given by:

$$\begin{aligned}
& p_i^K K_{ii}^H + p_i^L (L_{ii}^{HP} + L_{ii}^{HT}) + (p_j^K K_{ij}^H)_{(i \neq j)} + (p_j^L L_{ij}^{HP})_{(i \neq j)} \\
& = \{(p_i^K \theta^K \theta^X + p_i^L \theta^L) Y_{ij}^H\}_{(i=j)} + [\{(p_i^K \theta^K + p_i^L \tau_{ij}^X) \theta^X + p_j^L \theta^L\} Y_{ij}^H]_{(i \neq j)} \\
& \quad + \sum_j (p_j^K F_{ij}^H + p_j^L G_j). \tag{12}
\end{aligned}$$

As in the case of the type-N firm, the first term on the right-hand side of Equation (12) corresponds to the variable cost with respect to  $Y_{ij}^H$  ( $i=j$ ). The second term corresponds to the one with respect to  $Y_{ij}^H$  ( $i \neq j$ ). The third term is the total fixed cost.

### 2.2.3 Type-E Firm Established in Country $i$

A type-E firm produces four types of products: components  $X_{ij}^E$  ( $i=j$ ); components  $X_{iw}^E$ ; final products for the domestic market  $Y_i^{ED}$ ; and final products for the foreign market  $Y_{ijw}^{EF}$  ( $i \neq j$ ). The skilled labor requirements to produce one unit of a component in home country  $i$  can be expressed as:

$$K_{ii}^E = \theta^K (X_{ii}^E + X_{iw}^E) + F_{ii}^E, \tag{13}$$

where

- $K_{ii}^E$  is the skilled labor input hired in country  $i$ ;
- $X_{ii}^E$  is the quantity of components produced for the domestic plant;
- $X_{iw}^E$  is the quantity of components produced for the plant in country  $w$ ; and
- $F_{ii}^E$  is the fixed cost to establish a EMNE in country  $i$ .

To ship components  $X_{iw}^E$  from country  $i$  to a developing country  $w$ , the following amount of unskilled labor must be hired in country  $i$ :

$$L_i^{ET} = \tau_{iw}^X X_{iw}^E, \tag{13}$$

where

- $L_i^{ET}$  is the unskilled labor hired for international shipping; and
- $\tau_{iw}^X$  is the rate of trade cost for the international shipping of components.

The requirements for both unskilled labor and components to produce one unit of final products in home country  $i$  can be expressed as:

$$L_{ii}^{EP} = \theta^L Y_i^{ED} + G_i; \tag{15}$$

and

$$X_{ii}^E = \theta^X Y_i^{ED}, \tag{16}$$

where

- $L_{ii}^{EP}$  is the unskilled labor input hired in country  $i$ ; and
- $Y_i^{ED}$  is the quantity of final products assembled in country  $i$ .

Similarly, the requirements for both unskilled labor and components to produce one unit of final products in developing country  $w$  are:

$$L_{iw}^{EP} = \{(\theta^L + \tau_{jw}^Y)Y_{ijw}^{EF}\}_{(i \neq j)} + G_w; \quad (17)$$

and

$$X_{iw}^E = \theta^X Y_{ijw}^{EF}, \quad (18)$$

where

$L_{iw}^{EP}$  is the unskilled labor input hired in country  $w$ ;  
 $Y_{ijw}^{EF}$  is the quantity of final products assembled in country  $w$  for country  $j$ ;  
 $G_w$  is the fixed cost to set up an assembly plant in country  $w$ ; and  
 $\tau_{jw}^Y$  is the rate of trade cost for the international shipping of final products.

Similarly to the case of the type-H firm, skilled labor is needed at the local subsidiary to train unskilled labor how to handle the intermediate:

$$K_{iw}^E = F_{iw}^E, \quad (19)$$

where

$K_{iw}^E$  is the skilled labor input hired in country  $w$ ; and  
 $F_{iw}^E$  is the fixed cost to set up an assembly plant in country  $w$ .

Then, the cost function for a type-E firm is given by:

$$\begin{aligned} & p_i^K K_{ii}^E + p_i^L (L_{ii}^{EP} + L_{ii}^{ET}) + p_w^K K_{iw}^E + p_w^L L_{iw}^{EP} \\ &= (p_i^K \theta^K \theta^X + p_i^L \theta^L) Y_i^{ED} + \left[ \{(p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X + p_w^L (\theta^L + \tau_{jw}^Y)\} Y_{ijw}^{EF} \right]_{(i \neq j)} \\ & \quad + (p_i^K F_{ii}^E + p_i^L G_i + p_w^K F_{iw}^E + p_w^L G_w). \end{aligned} \quad (20)$$

Note that  $Y_{ijw}^{EF}(i=j) = 0$  and  $F_{ij}^E(i \neq j) = 0$ . The correspondence between the expressions on the right-hand side of Equation (18) and the variable or fixed cost is the same as before.

## 2.2.4 Type-V Firm Established in Country $i$

A type-V firm produces two types of products: components  $X_{iw}^V$ ; and final products for markets in developed countries  $Y_{ijw}^V$ . The skilled labor requirements to produce one unit of a component in home country  $i$  can be expressed as:

$$K_{ii}^V = \theta^K X_{iw}^V + F_{ii}^V, \quad (21)$$

where

$K_{ii}^V$  is the skilled labor input hired in country  $i$ ;  
 $X_{iw}^V$  is the quantity of components produced for the plant in country  $w$ ; and  
 $F_{ii}^V$  is the fixed cost to establish a VMNE in country  $i$ .

To ship components  $X_{iw}^V$  from country  $i$  to a developing country  $w$ , the following amount of unskilled labor must be hired in country  $i$ :

$$L_{ii}^V = \tau_{iw}^X X_{iw}^V, \quad (22)$$

where

$L_{ii}^V$  is the unskilled labor hired for international shipping; and  
 $\tau_{iw}^V$  is the rate of trade cost for the international shipping of components.

The requirements for both unskilled labor and components to produce one unit of final product in country  $w$  can be expressed as:

$$L_{iw}^V = \theta^L \sum_j Y_{ijw}^V + \sum_j \tau_{jw}^Y Y_{ijw}^V + G_w; \quad (23)$$

and

$$X_{iw}^V = \theta^X \sum_j Y_{ijw}^V, \quad (24)$$

where

$L_{iw}^V$  is the unskilled labor input hired in country  $w$ ; and  
 $Y_{ijw}^V$  is the quantity of final products assembled in country  $w$  for country  $j$ .

As in the previous cases, skilled labor is needed at the local subsidiary to train unskilled labor how to handle the intermediate:

$$K_{iw}^V = F_{iw}^V, \quad (25)$$

where

$K_{iw}^V$  is the skilled labor input hired in country  $w$ ; and  
 $F_{iw}^V$  is the fixed cost to set up an assembly plant in country  $w$ .

Then, the cost function for a type-E firm is given by:

$$\begin{aligned} & p_i^K K_{ii}^V + p_i^L L_{ii}^V + p_w^K K_{iw}^V + p_w^L L_{iw}^V \\ & = \{(p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X + p_w^L (\theta^L + \tau_{jw}^Y)\} Y_{ijw}^V + (p_i^K F_{ii}^V + p_w^K F_{iw}^V + p_w^L G_w). \end{aligned} \quad (26)$$

Note that  $F_{ij(i \neq j)}^V = 0$ . The first term on the right-hand side of Equation (26) corresponds to the variable cost with respect to  $Y_{ijw}^V$ , and the second term is the total fixed cost.

## 2.2.5 Production Volume of a Firm

In an equilibrium, the production volume of a firm in its respective type of production pattern is determined by a pricing relation that assures marginal revenue does not exceed marginal cost. The pricing relations for every type of production pattern can be expressed as:

$$p_j^Y (1 - \sigma_{ij}^N) \leq p_i^K \theta^K \theta^X + p_i^L (\theta^L + \tau_{ij(i \neq j)}^Y) \perp Y_{ij}^N; \quad (27)$$

$$p_j^Y (1 - \sigma_{ij}^H) \leq (p_i^K \theta^K + p_i^L \tau_{ij(i \neq j)}^X) \theta^X + p_j^L \theta^L \perp Y_{ij}^H; \quad (28)$$

$$p_j^Y(1 - \sigma_i^{ED}) \leq p_i^K \theta^K \theta^X + p_i^L \theta^L \quad \perp Y_i^{ED}; \quad (29)$$

$$p_j^Y(1 - \sigma_{ijw}^{EF}) \leq (p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X + p_w^L (\theta^L + \tau_{jw}^Y) \quad \perp Y_{ijw}^{EF}; \quad (30)$$

and

$$p_j^Y(1 - \sigma_{ijw}^V) \leq (p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X + p_w^L (\theta^L + \tau_{jw}^Y) \quad \perp Y_{ijw}^V, \quad (31)$$

where

$p_j^Y$  is the price of good  $Y$ ; and

$\sigma_{ijw}^q$  is the proportional markup of price over marginal cost ( $q = N, H, E, V$ ).

The perpendicular symbol “ $\perp$ ” shows the complementary slackness relationships between inequalities and endogenous variables. When a relation holds with equality, the corresponding variable takes a positive value.

The optimal markup in a Cournot model with homogeneous products is defined by the firm’s share divided by the Marshallian price elasticity of demand in the market. Because the Marshallian elasticity of demand is  $-1$  in the present model with Cobb-Douglas demand, a firm’s markup  $\sigma_{ijw}^q$  can be defined as:

$$\sigma_{ijw}^q \equiv \frac{p_j^Y Y_{ijw}^q}{\beta_j (p_j^K \bar{K}_j + p_j^L \bar{L}_j)}, \quad (32)$$

where

$\bar{K}_j$  is an exogenously given level of skilled labor endowment for country  $j$ ;

$\bar{L}_j$  is an exogenously given level of unskilled labor endowment for country  $j$ ; and

$\beta_j$  is the share of type- $Y$  goods in the representative consumer’s utility function.

Applying (32) to Relations (27) through (31) gives the following:

$$Y_{ij}^N \geq \beta_j (p_j^K \bar{K}_j + p_j^L \bar{L}_j) \left\{ \frac{p_j^Y - p_i^K \theta^K \theta^X - p_i^L (\theta^L + \tau_{ij(i \neq j)}^Y)}{(p_j^Y)^2} \right\} \quad \perp Y_{ij}^N; \quad (33)$$

$$Y_{ij}^H \geq \beta_j (p_j^K \bar{K}_j + p_j^L \bar{L}_j) \left\{ \frac{p_j^Y - (p_i^K \theta^K + p_i^L \tau_{ij(i \neq j)}^X) \theta^X - p_j^L \theta^L}{(p_j^Y)^2} \right\} \quad \perp Y_{ij}^H; \quad (34)$$

$$Y_i^{ED} \geq \beta_j (p_j^K \bar{K}_j + p_j^L \bar{L}_j) \left\{ \frac{p_j^Y - p_i^K \theta^K \theta^X - p_i^L \theta^L}{(p_j^Y)^2} \right\} \quad \perp Y_i^{ED}; \quad (35)$$

$$Y_{ijw}^{EF} \geq \beta_j (p_j^K \bar{K}_j + p_j^L \bar{L}_j) \left\{ \frac{p_j^Y - (p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X - p_w^L (\theta^L + \tau_{jw}^Y)}{(p_j^Y)^2} \right\} \quad \perp Y_{ijw}^{EF}; \quad (36)$$

and

$$Y_{ijw}^V \geq \beta_j (p_j^K \bar{K}_j + p_j^L \bar{L}_j) \left\{ \frac{p_j^Y - (p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X - p_w^L (\theta^L + \tau_{jw}^Y)}{(p_j^Y)^2} \right\} \quad \perp Y_{ijw}^V. \quad (37)$$

## 2.2.6 Number of Firms

Similarly to the production volume of a firm, number of firms in each type of production pattern is determined by a zero profit condition that assures markup revenue does not exceed fixed cost payment. The zero profit conditions for every type of production pattern can be expressed as:

$$\sum_j \sigma_{ij}^N p_j^Y Y_{ij}^N \leq p_i^K F_i^N + p_i^L G_i \quad \perp M_i^N; \quad (38)$$

$$\sum_j \sigma_{ij}^H p_j^Y Y_{ij}^H \leq \sum_j (p_j^K F_{ij}^H + p_j^L G_j) \quad \perp M_i^H; \quad (39)$$

$$\sigma_i^{ED} p_i^Y Y_i^{ED} + \sum_j (\sigma_{ijw}^{EF} p_j^Y Y_{ijw}^{EF})_{(i \neq j)} \leq p_i^K F_{ii}^E + p_i^L G_i + p_w^K F_{iw}^E + p_w^L G_w \quad \perp M_{iw}^E; \quad (40)$$

and

$$\sum_j \sigma_{ijw}^V p_j^Y Y_{ijw}^V \leq p_i^K F_{ii}^V + p_w^K F_{iw}^V + p_w^L G_w \quad \perp M_{iw}^V, \quad (41)$$

where

$M_i^N$  is the number of type-N firms established in country  $i$ ;

$M_i^H$  is the number of type-H firms established in country  $i$ ;

$M_{iw}^E$  is the number of type-E firms established in country  $i$  that have plants in  $w$ ;

$M_{iw}^V$  is the number of type-V firms established in country  $i$  that have plants in  $w$ ;

$Y_{ijw(i=j)}^{EF} = 0$ ;

$F_{ij(i \neq j)}^E = 0$ ; and

$F_{ij(i \neq j)}^V = 0$ .

Using Relations (27) through (31), (38) through (41) can be rewritten to:

$$\sum_j [\{p_j^Y - p_i^K \theta^K \theta^X - p_i^L (\theta^L + \tau_{ij(i \neq j)}^Y)\} Y_{ij}^N] \leq p_i^K F_i^N + p_i^L G_i \quad \perp M_i^N; \quad (42)$$

$$\sum_j [\{p_j^Y - (p_i^K \theta^K + p_i^L \tau_{ij(i \neq j)}^X) \theta^X - p_j^L \theta^L\} Y_{ij}^H] \leq \sum_j (p_j^K F_{ij}^H + p_j^L G_j) \quad \perp M_i^H; \quad (43)$$

$$\begin{aligned} & (p_j^Y - p_i^K \theta^K \theta^X - p_i^L \theta^L) Y_i^{ED} \\ & + \sum_j [\{p_j^Y - (p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X - p_w^L (\theta^L + \tau_{jw(i \neq j)}^Y)\} Y_{ijw}^{EF}] \\ & \leq p_i^K F_{ii}^E + p_i^L G_i + p_w^K F_{iw}^E + p_w^L G_w \quad \perp M_{iw}^E; \quad (44) \end{aligned}$$

and

$$\begin{aligned} & \sum_j [\{p_j^Y - (p_i^K \theta^K + p_i^L \tau_{iw}^X) \theta^X - p_w^L (\theta^L + \tau_{jw}^Y)\} Y_{ijw}^V] \\ & \leq p_i^K F_{ii}^V + p_w^K F_{iw}^V + p_w^L G_w \quad \perp M_{iw}^V. \quad (45) \end{aligned}$$

To summarize the type-Y good sector in the model, the output levels and number of firms categorized in the four types of production patterns are respectively determined by Inequalities (33) through (37) and (42) through (45), given the factor and commodity prices determined by the market-clearing conditions we will see later.



## 2.3 Type-Z Good Producer

A Type-Z good is produced in every country  $r$  with skilled and unskilled labor using a Cobb-Douglas CRTS technology under perfect competition. The production function is:

$$Z_r = \gamma_r (K_r^Z)^{\alpha_r} (L_r^Z)^{1-\alpha_r}, \quad (46)$$

where

$Z_r$  is the output volume of type-Z good in country  $r$ ;

$K_r^Z$  is the skilled labor input;

$L_r^Z$  is the unskilled labor input;

$\alpha_r$  is the share of skilled labor; and

$\gamma_r$  is a scaling factor of measuring units.

The producer in every country  $r$  chooses the levels of  $Z_r$ ,  $K_r^Z$ , and  $L_r^Z$ , to maximize profit subject to (46) given the prices of skilled and unskilled labor,  $p_r^K$  and  $p_r^L$ , and the output  $p^Z$ . The first order conditions (FOCs) for the optimum are given by:

$$p_r^K = \alpha_r p^Z \left( \frac{Z_r}{K_r^Z} \right), \quad (47)$$

and

$$p_r^L = (1 - \alpha_r) p^Z \left( \frac{Z_r}{L_r^Z} \right). \quad (48)$$

By Equations (46) through (48), the levels of  $Z_r$ ,  $K_r^Z$ , and  $L_r^Z$  are determined.

## 2.4 Consumer

The representative consumer in every country  $r$  maximizes her/his utility subject to their budget constraints given the price of commodities.

### 2.4.1 Consumer in Country $i$

The welfare level of a representative consumer in a developed (market) country  $i$  is assumed to be given by the following Cobb-Douglas utility function:

$$U_i = \delta_i (Y_i^U)^{\beta_i} (Z_i^U)^{1-\beta_i}, \quad (49)$$

where

$U_i$  is the welfare level of the representative consumer in country  $i$ ;

$Y_i^U$  is the consumption level of type-Y goods produced in the IRTS sector;

$Z_i^U$  is the consumption level of type-Z goods produced in the CRTS sector;  
 $\beta_i$  is the share of type-Y goods (mentioned in Subsection 2.2.5); and  
 $\delta_i$  is a scaling factor.

The budget constraint for the consumer is expressed as:

$$p_i^Y Y_i^U + p_i^Z Z_i^U = p_i^K \bar{K}_i + p_i^L \bar{L}_i, \quad (50)$$

where the expenditure enters the left-hand side, while the budget is sourced by factor income appearing in the right-hand side of Equation (50). Note that we implicitly assume balanced trade so that there are no foreign savings.

The representative consumer in country  $i$  chooses the consumption levels of  $Y_i^U$  and  $Z_i^U$  to maximize her/his utility defined by Equation (49) subject to (50). The FOCs for the optimum are:

$$\lambda_i p_i^Y = \beta_i \delta_i \left( \frac{Y_i^U}{Z_i^U} \right)^{\beta_i - 1}, \quad (51)$$

and

$$\lambda_i p_i^Z = (1 - \beta_i) \delta_i \left( \frac{Y_i^U}{Z_i^U} \right)^{\beta_i}, \quad (52)$$

where  $\lambda_i$  is the Lagrange multiplier with respect to budget constraint (50). By Equations (51) and (52), the levels of  $Y_i^U$  and  $Z_i^U$  are determined.

## 2.4.2 Consumer in Country $w$

The welfare level of the representative consumer in developing country  $w$  is measured solely by the consumption level of the type-Z good because the type-Y good is sold only in developed countries:

$$U_w = Z_w^U, \quad (53)$$

where

$U_w$  is the welfare level of the representative consumer in country  $w$ ; and  
 $Z_w^U$  is the consumption level of the type-Z good produced in the CRTS sector.

Similarly to the previous case, the budget constraint equates expenditure with factor income as follows:

$$p^Z Z_w^U = p_w^K \bar{K}_w + p_w^L \bar{L}_w. \quad (54)$$

Again, balanced trade is assumed.

The representative consumer in country  $w$  chooses the consumption level of  $Z_w^U$  to maximize her/his utility as defined by Equation (53) subject to (54). The FOC for the optimum is:

$$\lambda_w p^Z = 1, \quad (55)$$

where  $\lambda_w$  is the Lagrange multiplier with respect to budget constraint (54). By Equation (55), the level of  $Z_w^U$  is determined.

## 2.5 Market Equilibrium

The market-clearing conditions determine the price levels of the corresponding production factors and commodities in an equilibrium.

### 2.5.1 Factor Market Clearing

In each market country  $i$ , the following two labor market-clearing conditions hold in an equilibrium:

$$\begin{aligned} \bar{K}_i &= K_i^Z + M_i^N K_i^N + M_i^H K_{ii}^H + \sum_j (M_j^H K_{ji}^H)_{(i \neq j)} \\ &+ \sum_w M_{iw}^E K_{ii}^E + \sum_w M_{iw}^V K_{ii}^V, \end{aligned} \quad (56)$$

and

$$\begin{aligned} \bar{L}_i &= L_i^Z + M_i^N L_i^N + M_i^H (L_i^{HT} + L_{ii}^{HP}) + \sum_j (M_j^H L_{ji}^{HP})_{(i \neq j)} \\ &+ \sum_w M_{iw}^E (L_i^{ET} + L_{ii}^{EP}) + \sum_w M_{iw}^V L_{ii}^V. \end{aligned} \quad (57)$$

Equations (56) and (57), respectively, determine the levels of factor prices  $p_i^K$  and  $p_i^L$ .

In each developing country  $w$ , the following two market-clearing conditions hold in an equilibrium:

$$\bar{K}_w = K_w^Z + \sum_w M_{iw}^E K_{iw}^E + \sum_w M_{iw}^V K_{iw}^V, \quad (58)$$

and

$$\bar{L}_w = L_w^Z + \sum_w M_{iw}^E L_{iw}^{EP} + \sum_w M_{iw}^V L_{iw}^V. \quad (59)$$

The price levels of skilled and unskilled labor in country  $w$ ,  $p_w^K$  and  $p_w^L$ , are determined by Equations (58) and (59).

### 2.5.2 Commodity Market Clearing

The demand and supply of the two types of commodity for final consumption are equated to determine their price levels as follows:

$$Y_i^U = \sum_j (M_j^N Y_{ji}^N + M_j^H Y_{ji}^H + \sum_w M_{jw}^V Y_{jiw}^V) + \sum_j \left\{ M_{iw}^E Y_i^{ED} + \sum_j (M_{jw}^E Y_{jiw}^{EF})_{(i \neq j)} \right\}, \quad (60)$$

and

$$\sum_r Z_r^U = \sum_r Z_r. \quad (61)$$

By Equations (60) and (61), the price levels of both type-Y and type-Z goods,  $p_i^Y$  and  $p^Z$ , are determined.

Then, notice that one of the market-clearing conditions (56) through (61) automatically holds because of *Walras' Law*. Therefore, we drop Equation (61) from the system, treating the type-Z good as the numéraire. In consequence,  $p^Z$  is set to unity given exogenously.

## 2.6 System Equations/Inequalities

In the model, the output volumes of the type-Y good in each of the four types of production pattern ( $Y_{ij}^N$ ,  $Y_{ij}^H$ ,  $Y_i^{ED}$ ,  $Y_{ijw}^{EF}$ , and  $Y_{ijw}^V$ ), number of firms in the four types of production pattern ( $M_i^N$ ,  $M_i^H$ ,  $M_{iw}^E$ , and  $M_{iw}^E$ ), the output volume of the type-Z good ( $Z_r$ ), the input volume of skilled and unskilled labor in the production of the type-Z good ( $K_r^Z$  and  $L_r^Z$ ), the Lagrange multiplier with respect to the representative consumer's budget constraint in country  $i$  ( $\lambda_i$ ), the consumption levels of the two types of commodity by the representative consumer in country  $i$  ( $Y_i^U$  and  $Z_i^U$ ), the Lagrange multiplier with respect to the representative consumer's budget constraint in country  $w$  ( $\lambda_w$ ), the consumption/welfare level of the type-Z good by the representative consumer in country  $w$  ( $Z_w^U$ ), the price levels of skilled and unskilled labor in country  $i$  ( $p_i^K$  and  $p_i^L$ ), the price levels of the two types of labor in country  $w$  ( $p_w^K$  and  $p_w^L$ ), and the price level of the type-Y good ( $p_i^Y$ ) are determined by Inequalities (33) through (37) and (42) through (45), and Equations (46) through (48), (50) through (52), (54), (55), (56) through (59), and (60), respectively.

## 3. Numerical Implementation of the Model

Markusen (2002) noted that one may face two types of computational difficulty in the numerical application of an analytical model such as the one we introduced in the previous section. One is due to the high-dimensionality of the model, and the other is brought by the handling of inequalities. Versions of the knowledge-capital model, an objective of which is

to analyze emerging patterns of independent firm-types under different economic conditions, require us to appropriately manage corner-solutions based on the Karush-Kuhn-Tucker condition. For this reason, the model used in this study was coded in the General Algebraic Modeling System (GAMS) and solved by its PATH solver, which enables us to easily handle complementary slackness.<sup>1</sup>

In experimental simulations, we change the relative factor endowments for either the developed- or developing-country groups, given absolute levels of total endowments for the group. The factor endowments for the group not being focused on are kept identical for the two countries in the group. Then, a box diagram à la *Edgeworth box* is drawn placing the total skilled labor endowment for the focused group on the vertical axis and the total unskilled labor endowment on the horizontal axis to capture the regime, welfare level, factor prices, and so on in each cell corresponding to the relative factor endowments of the two countries.

The model is calibrated to the center of the box diagram, where the two countries in each group are totally identical. At this point, it is assumed that only HMNEs are active due to the existence of high trade cost between the two market countries in the base case. Then, there are no local subsidiaries and plants in the developing countries, and no trade with respect to the type-Z good takes place. Calibration of the model requires a set of information that includes a social accounting matrix (SAM), which corresponds to the center of the box diagram, levels of fixed and trade costs, and input coefficients. Especially, careful setting of the firm-type/trade-link specific fixed cost  $F$  is required because simulation results tend to be sensitive to this setting, in addition to the fact that the firm types other than type-H do not enter the given SAM.

### **3.1 Setting of the Firm-Type/Trade-Link Specific Fixed Cost $F$**

Let us recall the three important assumptions for the knowledge-capital model defined by Markusen (2002:129):

***Fragmentation:** the location of knowledge based assets may be fragmented from production. Any incremental cost of supplying services of the asset to a single foreign plant versus the cost to a single domestic plant is small.*

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<sup>1</sup> Brook, Kendrick, and Meeraus (1992) and Ferris and Munson (1998).

**Skilled-labor Intensity:** *knowledge-based assets are skilled labor intensive relative to final production.*

**Jointness:** *the services of knowledge based assets are (at least partially) joint (“public”) inputs into multiple production facilities. The added cost of a second plant is small compared to the cost of establishing a firm with local plant.*

The values of parameters such as fixed and trade costs should be set in line with these three properties, because a firm’s decisions to choose which operational type under a certain economic condition are crucially motivated by these properties.

Based on the three properties, we make the following four assumptions on the firm-type/trade-link specific fixed cost  $F$  for a firm established in country  $A$ :

$$2F_A^N > F_{AA}^H + F_{AB}^H > F_A^N, \quad (62)$$

$$F_{AA}^E \geq F_{AA}^H > F_A^N > F_{AA}^V, \quad (63)$$

$$F_{AB}^H > F_{AC}^E = F_{AD}^E = F_{AC}^V = F_{AD}^V, \quad (64)$$

and

$$F_{AA}^H + F_{AB}^H > F_{AA}^E + F_{AC}^E = F_{AA}^E + F_{AD}^E > F_{AA}^V + F_{AC}^V = F_{AA}^V + F_{AD}^V > F_A^N. \quad (65)$$

The case for a firm established in country  $B$  is the same. Relation (62) is based on the jointness assumption shown above.

Relation (63) is related to the headquarter cost. First, a type-H firm is costly compared to a type-N firm because additional skilled labor is required in the headquarters for managerial and coordination activities. Second, the additional cost of managerial and coordination activities for the operation of a local subsidiary might be higher in a developing country (type-E) than in a developed country (type-H). Third, a type-N firm is costly compared to a type-V firm because the latter may hire local skilled labor to train unskilled labor at a cheaper price in the host country.

Relation (64) is related to the local affiliate cost. In developing countries, cheaper skilled labor is available.

Relation (65) is related to the total cost. A type-V firm is less costly compared to the cases of type-H and type-E because it has only one assembly plant in a developing country so that the additional payment for managerial coordination activities is not required. Among the type-H and type-E firms, we assume that operating an assembly plant is more costly in a developed country than in a developing country. Relation (65) also implies that technology transfer incurs some amount of cost so that fragmentation is not perfect.

Finally, the parameter values for the firm-type/trade-link specific fixed cost  $F$  are set as follows:

$$\begin{aligned} F_i^N &= 4.2; \\ F_{ij}^H &= 4.4 \ (i = j), 1.6 \ (i \neq j); \\ F_{ir}^E &= 4.4 \ (r = i), 0 \ (r \neq i), 1.5 \ (r = w); \text{ and} \\ F_{ir}^V &= 3.6 \ (r = i), 0 \ (r \neq i), 1.5 \ (r = w). \end{aligned}$$

These values tend to be set high to perform comparative statics between the base case and a counterfactual equilibrium where some of the values are set substantially lower.

### 3.2 Calibration Based on a Social Accounting Matrix

Along with the firm-type/trade-link specific fixed cost, trade costs related to the two types of commodity, intermediate and final goods, and input coefficients are assumed as follows:

$$\begin{aligned} \tau_{ir}^X &= \tau_{jr}^Y = 0.2; \\ \theta^K &= 1; \\ \theta^L &= 0.875; \text{ and} \\ \theta^X &= 0.125. \end{aligned}$$

In addition, initial levels of prices are given as a usual cliché in the parameterization process of a general equilibrium model, in which not absolute but only relative levels of prices matter:

$$\begin{aligned} p_w^K &= p_w^L = p^Z = 1; \text{ and} \\ p_i^Y &= 1.25. \end{aligned}$$

Then, the initial values of some endogenous variables and a part of the country specific setup cost  $G$  are calibrated from a SAM. In this study, we assume the following value is obtained from a SAM.

$$\beta_j(p_j^K \bar{K}_j + p_j^L \bar{L}_j) = 100.$$

In the second step, the initial values of  $Y_{ij}^H$  is calculated using Equation (34):

$$Y_{ij}^H = 16 \ (i = j), 14.4 \ (i \neq j).$$

Third,  $M_i^H$  is derived using the following relation:

$$M_i^H = \frac{\beta_i(p_i^K \bar{K}_i + p_i^L \bar{L}_i)}{\sum_j p_i^Y Y_{ji}^H} = \frac{100}{38}.$$

$\sigma_{ij}^H$  is also obtained by Equation (32):

$$\sigma_{ij}^H = 0.2 \ (i = j), 0.18 \ (i \neq j).$$

Finally,  $G_j$  is calibrated using Equation (43) because the two market countries are identical:

$$G_j = 0.62.$$

Based on this calibrated value,  $G_w$  is also set to 0.62 in the base case.

The whole picture of the SAM assumed in this study is shown in Table 1, where  $TC_i^H$ ,  $U_r$ ,  $MR_{ij}^H$ ,  $FC_i^H$ ,  $I_r$ , and  $E_i$  denote total cost, consumption, markup revenue, fixed cost, income of a representative consumer, and income of the type-H firms owner, respectively.

	$Z_A$	$Z_B$	$Z_C$	$Z_D$	$M_A^H Y_{AA}^H$	$M_A^H Y_{AB}^H$	$M_B^H Y_{BA}^H$	$M_B^H Y_{BB}^H$	$FC_A^H$	$FC_B^H$	$U_A$	$U_B$	$U_C$	$U_D$	$I_A$	$I_B$	$I_C$	$I_D$	$E_A$	$E_B$	Total	
$Z_A^U$	100.00										-100.00										0	
$Z_B^U$		100.00										-100.00										0
$Z_C^U$			200.00										-200.00									0
$Z_D^U$				200.00										-200.00								0
$Y_A^U$					52.63		47.37				-100.00											0
$Y_B^U$						47.37		52.63				-100.00										0
$TC_A^H$									19.05											-19.05		0
$TC_B^H$										19.05											-19.05	0
$L_A$	-80.00				-36.84		-34.11		-1.63	-1.63					154.21							0
$L_B$		-80.00				-34.11		-36.84	-1.63	-1.63						154.21						0
$L_C$			-154.21														154.21					0
$L_D$				-154.21														154.21				0
$K_A$	-20.00				-5.26	-4.74			-11.58	-4.21					45.79							0
$K_B$		-20.00					-4.74	-5.26	-4.21	-11.58						45.79						0
$K_C$			-45.79														45.79					0
$K_D$				-45.79														45.79				0
$U_A$											200.00				-200.00							0
$U_B$												200.00				-200.00						0
$U_C$													200.00				-200.00					0
$U_D$														200.00				-200.00				0
$MR_{AA}^H$					-10.53														10.53			0
$MR_{AB}^H$						-8.53														8.53		0
$MR_{BA}^H$							-8.53														8.53	0
$MR_{BB}^H$								-10.53													10.53	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1: Social Accounting Matrix for the Center of the Box Diagram

In this case, we presume that all of the four countries have the same amount of factor endowments. In the later simulation experiments, we will consider different country sizes for the developing group.

Using this SAM, the parameters in the two Cobb-Douglas aggregator functions (46) and (49),  $\alpha_r$ ,  $\beta_i$ ,  $\gamma_r$ , and  $\delta_i$ , are calibrated.

## 4. Simulations

We now report on the results of simulations performed with the extended knowledge-capital model introduced previously. The simulations are categorized into two



groups. The first one is to reveal some of the behavioral characteristics of the model, and the second is to examine whether a free trade agreement (FTA) or an economic partnership agreement (EPA) would be effective for a developing country to stimulate incoming FDI, in a situation where the country is left behind another developing rival in forming a free-trade area with one of the developed countries where there is a market for the MNE’s final products. In the simulations, we change the relative factor endowments for either the developed- or developing-country groups given absolute levels of total endowments for the group, and we calculate every equilibrium of the economy under the selected sets of national endowments. The factor endowments for the group not under focus are kept identical to two the members in the group. Then, trade and fixed costs are respectively reduced from their initial values set in the base case to see how the pattern of regimes changes.

### 4.1 Basic Characteristics of the Model

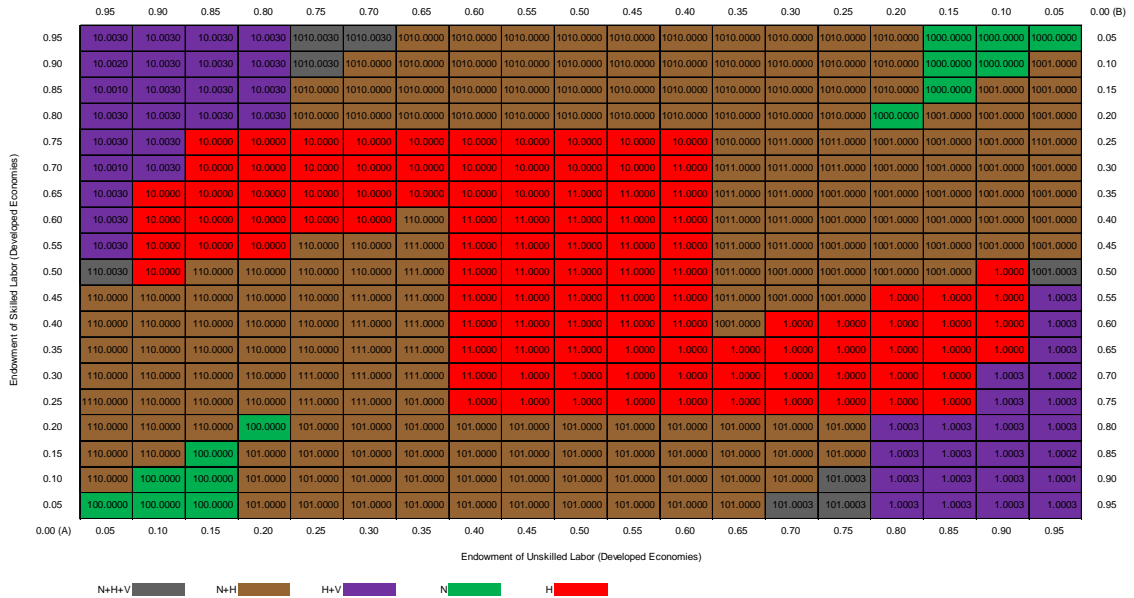


Figure 2: Equilibrium Regime in the Base Case (Developed Countries)

Figure 2 is a box diagram for the case when relative factor endowments for the developed (market) countries are changed given the absolute levels of total endowments shown in the benchmark SAM (Table 1). This will be the base case for comparison with the results

obtained when a set of parameters or exogenous variables are changed. The initial levels of trade and fixed costs assumed in the base case are:

$$\begin{aligned}\tau_{ir}^X &= \tau_{jr}^Y = 0.2; \\ F_i^N &= 4.2; \\ F_{ij}^H &= 4.4 \ (i = j), 1.6 \ (i \neq j); \\ F_{ir}^E &= 4.4 \ (r = i), 0 \ (r \neq i), 1.5 \ (r = w); \\ F_{ir}^V &= 3.6 \ (r = i), 0 \ (r \neq i), 1.5 \ (r = w); \text{ and} \\ G_r &= 0.62.\end{aligned}$$

In the box, the vertical axis corresponds to the total endowment of skilled labor for the two developed countries, and the horizontal axis to that of unskilled labor. The division of the factor endowments between the two countries is shown with country *A* measured from the southwest (SW) corner and country *B* measured from the northeast (NE) corner. The model is repeatedly solved for each cell 361 (19×19) times, altering the distribution of factor endowments. Each cell represents an equilibrium regime and the number inside shows which type of firm is active in the regime. The regime number is defined as:

$$\begin{aligned}\Omega &= \omega_A^N + \omega_B^N + \omega_A^H + \omega_B^H + \omega_{AC}^E + \omega_{AD}^E + \omega_{BC}^E + \omega_{BD}^E \\ &\quad + \omega_{AC}^V + \omega_{AD}^V + \omega_{BC}^V + \omega_{BD}^V,\end{aligned}$$

where

$$\begin{aligned}\omega_A^N &= 1000 \text{ if Type-N firms established in country } A \text{ are active, otherwise } 0; \\ \omega_B^N &= 100 \text{ if Type-N firms established in country } B \text{ are active, otherwise } 0; \\ \omega_A^H &= 10 \text{ if Type-H firms established in country } A \text{ are active, otherwise } 0; \\ \omega_B^H &= 1 \text{ if Type-H firms established in country } B \text{ are active, otherwise } 0; \\ \omega_{AC}^E &= 0.1 \text{ if Type-E firms established in country } A \text{ operating in country } C \\ &\quad \text{are active, otherwise } 0; \\ \omega_{AD}^E &= 0.2 \text{ if Type-E firms established in country } A \text{ operating in country } D \\ &\quad \text{are active, otherwise } 0; \\ \omega_{BC}^E &= 0.01 \text{ if Type-E firms established in country } B \text{ operating in country } C \\ &\quad \text{are active, otherwise } 0; \\ \omega_{BD}^E &= 0.02 \text{ if Type-E firms established in country } B \text{ operating in country } D \\ &\quad \text{are active, otherwise } 0; \\ \omega_{AC}^V &= 0.001 \text{ if Type-V firms established in country } A \text{ operating in country } C \\ &\quad \text{are active, otherwise } 0; \\ \omega_{AD}^V &= 0.002 \text{ if Type-V firms established in country } A \text{ operating in country } D \\ &\quad \text{are active, otherwise } 0; \\ \omega_{BC}^V &= 0.0001 \text{ if Type-V firms established in country } B \text{ operating in country } C\end{aligned}$$

are active, otherwise 0; and

$$\omega_{BD}^V = 0.0002 \text{ if Type-V firms established in country } B \text{ operating in country } D \text{ are active, otherwise } 0.$$

Figure 2 shows that only type-H firms are active around the center of the box diagram, where two developed countries are similar in both size and relative endowment. If the countries are different in size while being similar in relative endowment, type-N firms established in the country with abundant factors dominate the production and occupy both markets, as confirmed around the SW and NE corners. When the price of unskilled labor in a market country becomes cheaper, foreign type-H firms become active in the country, as confirmed in the northwest (NW) and southeast (SE) neighborhoods surrounding the central area. Toward the NW corner from the center, the price of skilled/unskilled labor in country *A* becomes lower/higher while that in country *B* goes opposite. Toward the SE corner, it reverses. Thus, firms in a market country where the price of unskilled labor becomes extremely high, go out to developing countries as type-V firms, as confirmed around the NW and SE corners.

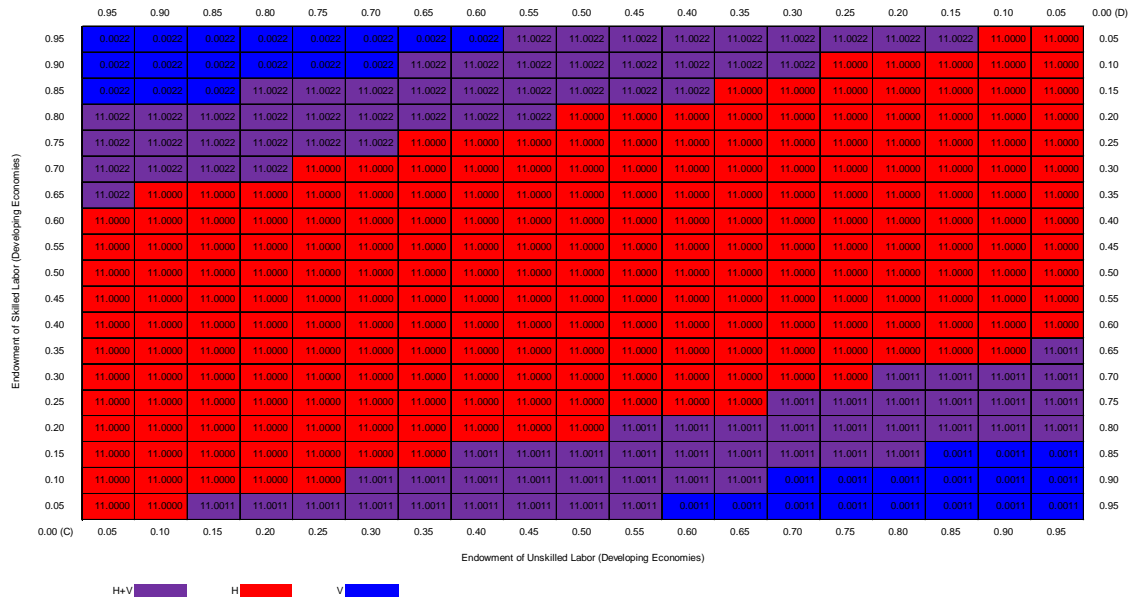


Figure 3: Equilibrium Regime in the Base Case (Developing Countries)

Figure 3 is a box diagram for the case when relative factor endowments for the developing countries are changed and absolute levels of total endowments for the group are

given. This is also the base case. Figure 3 shows that around the center and the SW and NE corners, where developing countries are similar in relative endowment, MNEs never setup plants in developing countries but go straight to the market countries as type-H firms. This occurs because there is no substantial difference between relative factor prices among the countries. On the other hand, around the NW and SE corners where cheaper skilled labor is available in either of the developing countries, type-V firms become active. For instance, around the SE corner, skilled labor is relatively abundant in country  $C$  so that type-V firms from both countries  $A$  and  $B$  operate in  $C$ . Around the NW corner, firms operating in country  $D$  prevail. Note that, in this base case captured by Figures 2 and 3, type-E firms never show up.

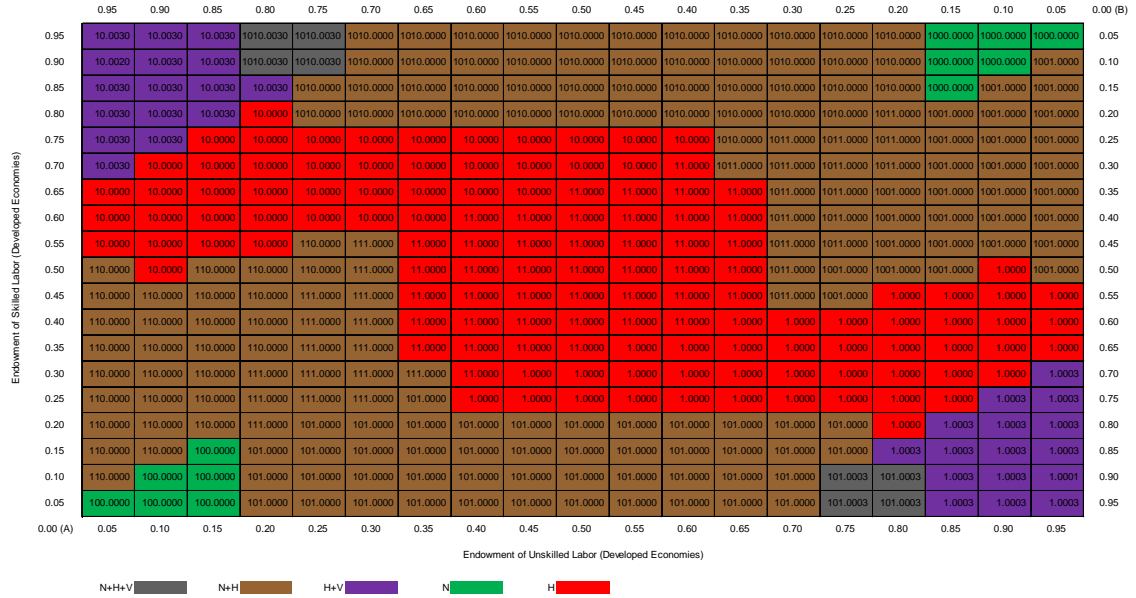


Figure 4: Lower Trade Cost of Components ( $\tau_{ir}^X = 0.04$ , Developed Countries)

Next, let us see what happens when selected values of trade and fixed costs change. When the trade cost of components concerning all trade-links is lowered, type-H firms extend their influence (Figure 4). It is quite natural that sending components to foreign countries becomes cheaper in this case. As the type-H firms increase, the incentive to operate in developing countries as a type-V firm becomes weak.

When the trade cost of finished products concerning all trade-links is lowered, type-N firms increase (Figure 5). This is also natural in that exporting finished products to

foreign countries becomes cheaper in this case. The type-N firms extend their influence along the SW-NE diagonals where the relative endowment of countries and factor prices tend to be similar. On the other hand, if there is a difference in factor availability even to a slight extent, the firms established in the larger country dominate the production and occupy both markets, as in the previous case. The incentive to operate in developing countries is still weak as in the case of the trade cost of components.

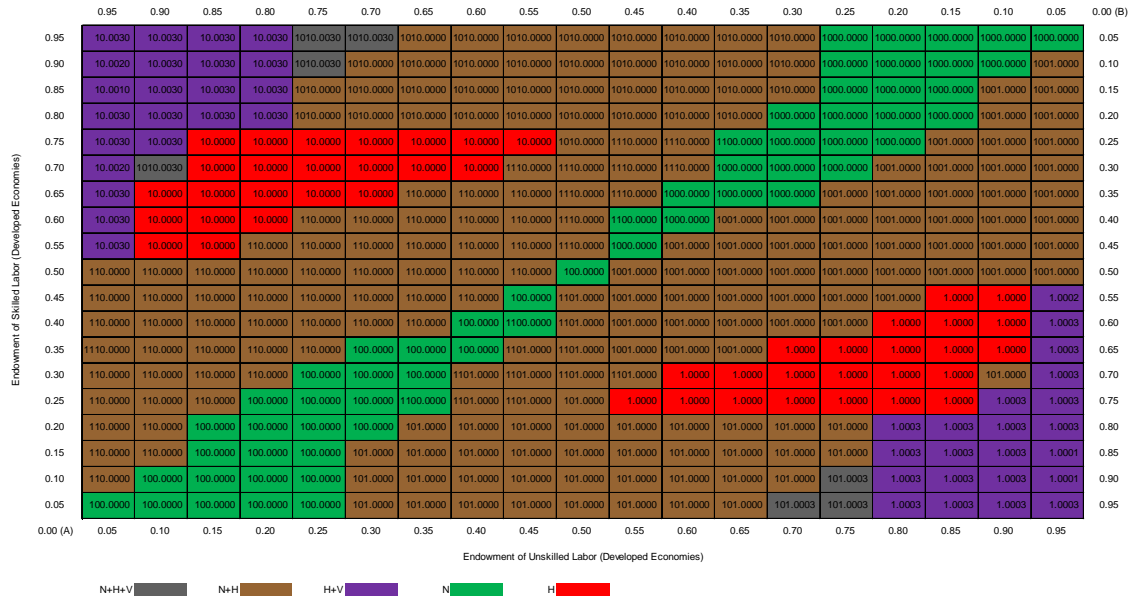


Figure 5: Lower Trade Cost of Finished Products ( $\tau_{lr}^Y = 0.04$ , Developed Countries)

If the change in trade cost of finished products is limited to only the trade-link between countries  $A$  and  $C$ , type-V firms established in  $A$  increases in  $C$ , as confirmed around the NW corner in Figure 6, where the price of unskilled labor in country  $A$  is high. Although type-V firms in country  $A$  operate in both developing countries  $C$  and  $D$  around this area in the base case, all of the type-V firms change their operational location to  $C$  in this case. Therefore, it can be said that liberalizing imports of finished products from a developing country motivates firms in the liberalizing country to set up local affiliates in the objective country.

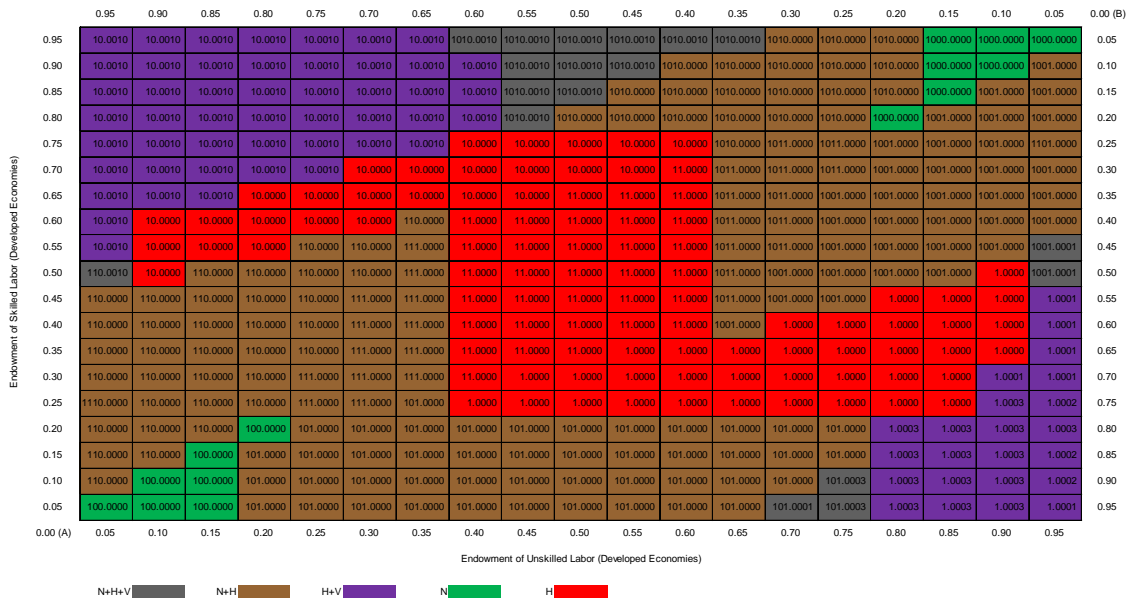


Figure 6: Lower Trade Cost of Finished Products ( $\tau_{AC}^Y = 0.04$ , Developed Countries)

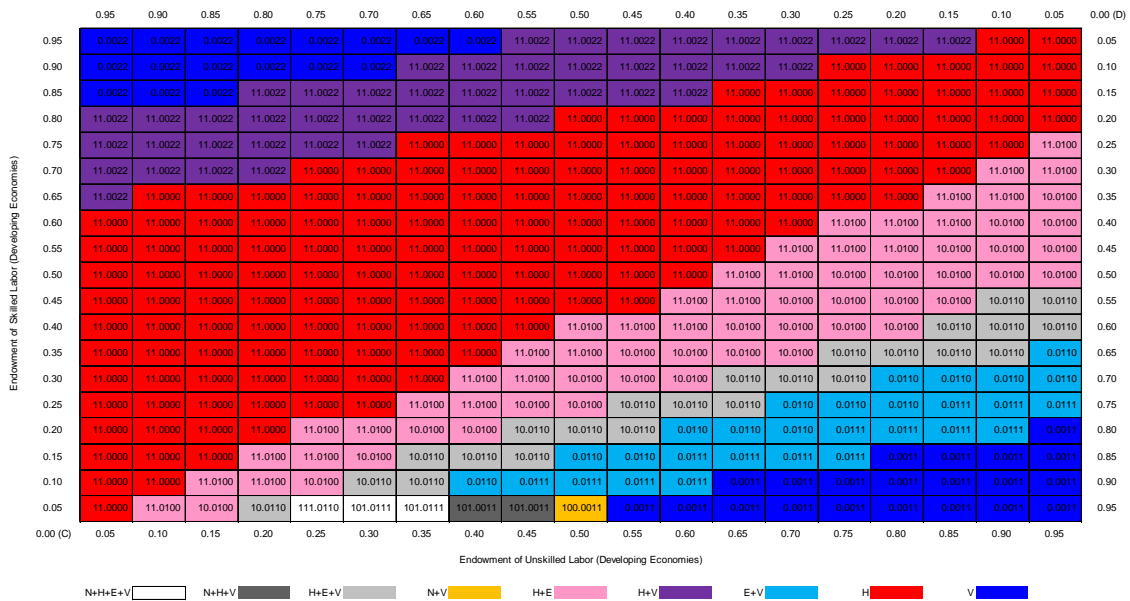


Figure 7: Lower Trade Cost of Finished Products ( $\tau_{AC}^Y = 0.04$ , Developing Countries)

When two developing countries differ in size and relative factor endowment, lowering the trade cost of finished products concerning the trade-link just between countries *A* and *C* motivates firms in country *B* to be type-E and operate in country *C*.

This phenomenon is obvious around the SE part in Figure 7, where the price of unskilled labor in country  $C$  is relatively cheap. This result is consistent with the one obtained by Ekholm, Forslid, and Markusen (2007). Thus, type-E firms tend to arise in the low-cost countries in a free-trade area to serve the market in the FTA member.

Finally, no substantial difference can be observed with respect to other items, such as the country specific fixed cost  $G$  or the firm-type/trade-link specific cost  $F$ , from the base case patterns in either case when relative factor endowments for the developed and developing countries respectively are changed. The effects of independently controlling fixed costs on the type of active firms seem not to be large compared to those of trade cost in the present setting.

## 4.2 Experiments: Is FTA/EPA Effective for a Developing Country to Attract FDI?

Let us proceed to more scenario-oriented simulations. With these experiments, we examine the effects of liberalizing trade between a pair of developed (market) and developing countries and of implementing cost-saving policies, such as standardizing rules or simplifying procedures related to opening business in the member countries, assuming the situation that the developing country in question is left behind of another rival in settling an economic partnership. Suppose that the country is in need of FDI to accelerate economic growth to catch up with rival countries.

To simulate trade liberalization between a pair of developed and developing countries, both  $\tau_{iw}^X$  and  $\tau_{jr}^Y$  are set to 0.05 (25% of the initial level). Let us call this case “FTA”. The additional cost-saving policy is expressed by lowering both  $F_{iw}^E$  and  $F_{iw}^V$  by half (0.7). We call the set of FTA plus this additional policy “EPA”. The initial levels of trade and fixed costs before any country settles free trade are set to:

$$\begin{aligned}\tau_{ir}^X &= \tau_{jr}^Y = 0.2; \\ F_i^N &= 4.2; \\ F_{ij}^H &= 4.4 \ (i = j), 1.6 \ (i \neq j); \\ F_{ir}^E &= 4.4 \ (r = i), 0 \ (r \neq i), 1.4 \ (r = w); \\ F_{ir}^V &= 3.6 \ (r = i), 0 \ (r \neq i), 1.4 \ (r = w); \text{ and} \\ G_r &= 0.62 \ (r = i), 0.31 \ (r = w).\end{aligned}$$

Notice that the levels of  $F_{iw}^E$ ,  $F_{iw}^V$ , and  $G_w$  are set slightly lower than in the previous simulations to consider lower factor costs in developing countries. It can also be supposed that the developing countries have already started implementing cost-saving policies such

as construction of special economic zones and industrial parks.

## 4.2.1 Basic Environment

Onto the setting we observed previously, we introduce the situation that FTA between countries  $A$  and  $C$  has already been implemented. This is expressed by setting  $\tau_{AC}^X = \tau_{AC}^Y = 0.05$ . Figure 8 is a box diagram for the economic environment before country  $D$  concludes FTA with any market country. The regime pattern closely resembles the one captured in Figure 7 ( $\tau_{AC}^Y = 0.04$ ). In the SE area, where the price of unskilled labor is relatively low, type-V firms from both developed countries  $A$  and  $B$ , and type-E firms from country  $B$  operates in country  $C$ . As the central part of the box is approached, it implies that the relative price of skilled to unskilled labor falls, and firms established in country  $B$  change their form from type-V to type-E.

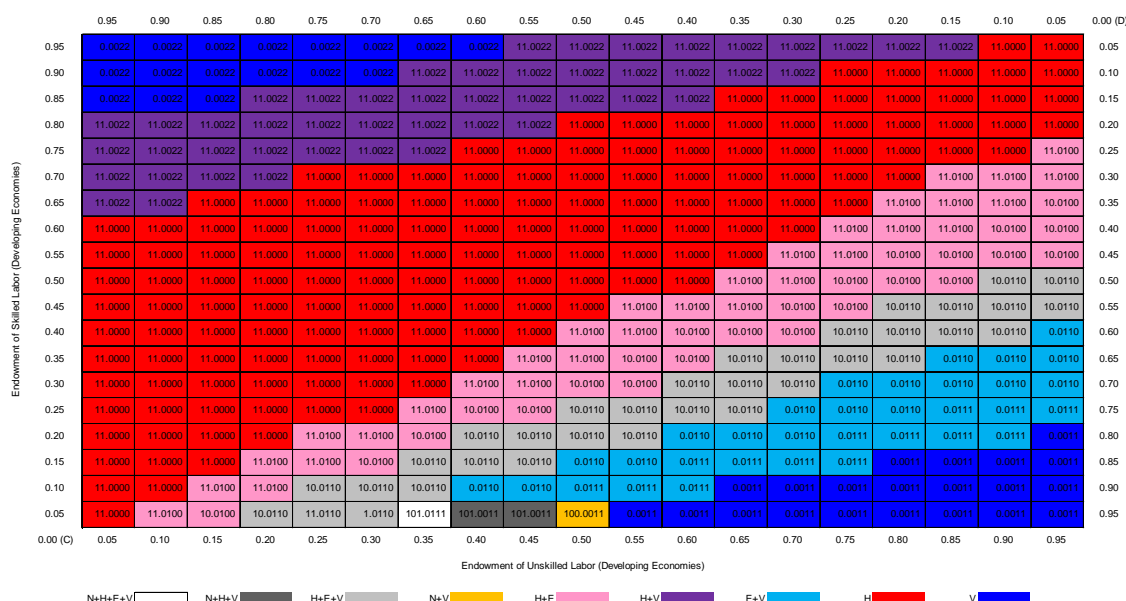


Figure 8: FTA between Countries  $A$  and  $C$  (Developing Countries)

Note that the size of the area at the SE corner, where only type-V firms are active, shrinks as the absolute level of total endowments for the developing countries become smaller. As we test different sizes of developing countries from double to half the size of the developed countries, the impact on factor prices of one unit of foreign firm entrance



becomes large for a small-sized country.

## 4.2.2 Effects of FTA/EPA with Country $D$ on Firm Type

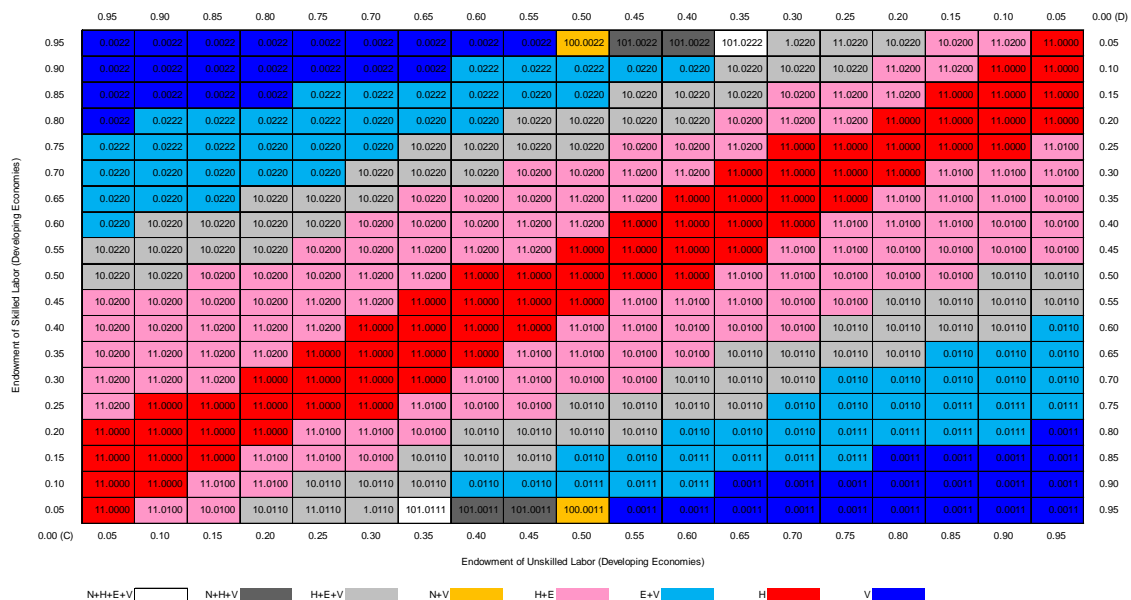


Figure 9: FTA with Countries  $D$  (Developing Countries)

Suppose country  $D$  liberalizes trade with one of the market countries. When country  $A$  is selected, it is expressed by setting  $\tau_{AD}^X = \tau_{AD}^Y = 0.05$ . Figure 9 shows the regime pattern when both countries  $C$  and  $D$  have liberalized trade with country  $A$ . It is clear that the perfectly identical pattern appears in the opposite corner leaving the pattern around the SE corner completely unaffected. In this case, a group of type-H firms established in country  $B$  turn into type-E firms and start operating in country  $D$  to serve the market in country  $A$ . The participation of country  $D$  in the partnership with country  $A$  will not affect the welfare level or factor prices in country  $C$ . Furthermore, country  $D$ 's choice of FTA partner will not affect the regime pattern, as well as welfare levels and factor prices in both developing countries  $C$  and  $D$ , in the present setting wherein the two developed countries are perfectly symmetric. The difference can be found in the nationality of the firms operating in country  $D$ , and in welfare levels in the market countries. If country  $D$ 's FTA partner is changed to country  $B$ , type-E firms from country  $B$  are replaced by those from country  $A$ . In consequence, type-E firms from country  $A$  and type-V firms from country

$B$  start operating in country  $D$ . The welfare level in the country that settles FTA with country  $D$  improves, while the country that has not been chosen as the FTA partner is worse off.

Another important point is that MNEs will not operate in developing countries even though FTAs take place if their relative factor endowments are similar. To attract inward FDI, a developing country must have substantially cheap unskilled labor based on the rich relative endowment of the factor.

Next, let us consider the case that country  $D$  settle an economic partnership program in which a cost-saving policy related to firm-type/trade-link specific fixed cost is added to a regular FTA with one of the developed countries. It is expressed by setting  $F_{iD}^E = F_{iD}^V = 0.7$ . Again, country  $D$ 's choice of FTA partner does not matter apart from the welfare levels of the developed countries. Hence, either country  $A$  or  $B$ , whichever is selected as the FTA partner, is applied to the suffix  $i$  in  $F_{iD}^E$  and  $F_{iD}^V$ . Note that the FTA between countries  $A$  and  $C$  does not include this additional option. The purpose is to see whether the subsequent starter, country  $D$ , can go further beyond the forerunner, country  $C$ .

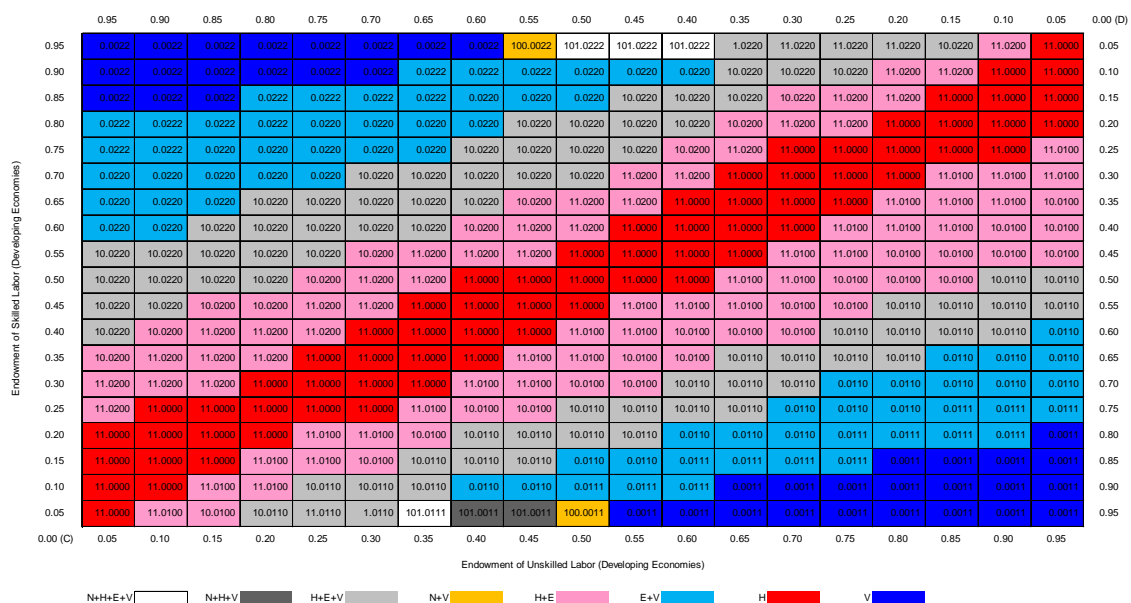


Figure 10: EPA with Country  $D$  (Developing Countries)

Figure 10 shows the regime pattern when country  $A$  simultaneously establishes FTA with country  $C$  and EPA with country  $D$ . As expected, type-H firms slightly lose



model, which does not consider any spillover effects from inward FDI that may help to enhance long-run growth rates, the advantage of having an assembly plant is just in the fact that it may increase income through affecting factor prices by extra demand for skilled and unskilled labor. Therefore, factor prices play an important role as the source of welfare gains. In the meantime, the implementation of FTA by country  $D$  never affects the welfare level or factor prices in country  $C$ , as mentioned before.

Table 2 shows the effects of implementing FTA between country  $D$  and one of the market countries on welfare and factor prices. All values are in terms of percentage change with respect to the level of the corresponding item at the base case, which is captured by the benchmark SAM (Table 1). Hence, every value at the center of the box diagram becomes zero because we calibrated the model at the center of the diagram.

Notice that the FTA brings negative effects on welfare in the neighboring cells around the NW corner (table on the top). This is the result of changes in price of the two factors. As the table in the middle shows, the price of skilled labor changes its sign from positive to negative if we trace the values from the NW corner to the center. In contrast, the price of unskilled labor changes its signs from negative to positive (table at the bottom). The cells that show negative welfare impact correspond to the points where the total income from both skilled and unskilled labor is lower than the base case. When the total endowments for the developing countries are smaller, the possibility of facing welfare losses is lower. On the other hand, the possibility grows as the total endowments become larger. This is because the rate of change of factor prices per unit increase of assembly plant becomes large in a small-sized country. Another way to avoid welfare losses is to increase the availability of skilled labor in the country. Investing to educate nations and other efforts to accumulate human capital may help.

Next, Table 3 shows the effects of implementation of cost-saving policies in addition to FTA between country  $D$  and one of the market countries. The supplement may enhance welfare gains from the FTA except the case when country  $D$  is extremely lacking in skilled labor. This is because lowering the firm-type/trade-link specific fixed cost saves skilled labor input, so that the factor turns out to be redundant and the impact on its price becomes relatively large in a country where skilled labor is scarce. This also happens in the case when the total endowments for the developing countries are smaller. Efforts to increase skilled labor in the country also work here to avoid welfare losses.



1. When two developing countries differ in size and relative factor endowment, lowering the trade cost of finished products concerning a trade-link between a market country and a developing country motivates firms in a country “not” on the link to be an export-platform MNE operating in the developing country on the link.
2. MNEs will not setup plants in developing countries if their relative factor endowments are similar even when FTA takes place between some of those countries and a country where there is a market for the commodity produced by the MNE. To attract inward FDI, a developing country must have substantially cheap unskilled labor based on a rich relative endowment of this factor.
3. In the present setting wherein two market countries are perfectly symmetric, a developing country’s choice of FTA partner from among the market countries will not affect the production pattern of firms, welfare levels, or factor prices in the developing countries. On the other hand, the welfare level in the market country that settles the FTA with a developing country improves, while the market country that has not been chosen as the FTA partner is worse off.
4. Although FTA/EPA generally tends to increase FDI to a developing country, the possibility to improve welfare through increased demand for skilled and unskilled labor becomes higher as the size of the country declines. This is because the rate of change of factor prices per unit assembly plant increase becomes large in a small-sized country.
5. As the size of a developing country grows, the possibility of facing welfare losses through FTA/EPA becomes higher. To avoid this problem, policies to increase the availability of skilled labor in the country, such as investing in education, may help.
6. Because the additional implementation of cost-saving policies to reduce firm-type/trade-link specific fixed costs tends to depreciate the price of skilled labor by saving its input, a developing country, in which skilled labor is extremely scarce, is better off avoiding the additional option because the negative impact on the skilled labor price is relatively large. If the country chooses to pursue larger welfare gains with EPA, efforts to increase skilled labor may also work here.

There are several potentially important issues that we have not yet taken into account in our analytical framework. First, the present model does not consider any spillover effects from inward FDI that may contribute to enhance long-run growth rates. Inclusion of such positive effects possibly brought by FDI will change some of the results listed above (#4 and #5). Second, the production of components in foreign market countries and in developing countries is obvious in the real economy. Although such a model must be highly complicated, it is worth challenging. Finally, the model does not include a firm-type called “complex integration” proposed by Yeaple (2003) and studied by Grossman, Helpman, and Szeidl (2006), which is a combination of the type-H firm serving for the foreign market and the type-V firm for the home market. The next version of our model will definitely come with this type.

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