FDI VS EXPORTS IN A GENERAL EQUILIBRIUM RICARDIAN MODEL

Abstract

In a two-country general equilibrium Ricardian model, we propose a model in which countries compete in the same sectors via exports or FDI. Factor endowments are important in that they affect relative wages and the range of goods countries produce. Effects of factor endowments on FDI depend on the interaction of FDI and trade barriers. Transportation costs do favor FDI at the expense of exports, but reduce trade and investment. Finally, in contrast to the new trade theory, across industries, it is the *relatively* less productive firms that engage in FDI while the *relatively* more productive firms export.

JEL Classification: F11, F12

Key Words: Foreign Direct Investment, General Equilibrium, Exports, International Trade

I. INTRODUCTION

A question central to international economics is why do some firms produce only for the home market, other firms produce at home for both the home and foreign market, and still other firms produce at home for the home market and abroad for the foreign market? Numerous answers to this question have been suggested. They range from firm level heterogeneities (e.g. Helpman, et al., 2004), to incomplete contracts (e.g. Helpman & Krugman, 1985; Antrás, 2005), to factor endowments (Cole & Elliott, 2005; Gopinath & Chen, 2003), to trade barriers (e.g. Nicoletti et al., 2003; Raff & Srinivasan, 1998), to scale economies (e.g. Brainard, 1993; Horstmann & Markusen, 1992). Markusen (1995) provides a thorough examination of the evidence in the context of a set of macro and microeconomic facts of foreign direct investment (FDI) that have not been fully explained in the theoretical literature. Among these, at the macro level, are that most FDI is from one developed country to another, FDI flows are two-way between pairs of developed countries, most FDI is horizontal so that FDI and exports are substitutes, and factor endowments and trade barriers are not the main determinants of FDI flows. At the micro level, multinationals tend to be firms for which intangible, firm-specific assets, such as proprietary knowledge, are important. Further, FDI increases relative to trade as trade barriers increase, but both trade and investment are reduced.

In this paper we develop a model that is motivated both by the existing theoretical literature and by Markusen's stylized facts. We develop a general, rather than partial, equilibrium Ricardian model, based on Dornbusch et al. (1977), in which there exists a continuum of industrial sectors each populated by a continuum of potential firms rather than a single sector with a continuum of firms. Firms have access to technologies, which are specific to the firm's country of origin, in their sector. Thus, in contrast to Helpman, et al. (2004), there are no differences in within country – within sector productivity (all domestic firms operating in a sector, whether at home or abroad, are identical), rather productivity differences are across countries and across sectors, both within and across countries. Markets are competitive rather than monopolistically competitive. Our general equilibrium approach emphasizes the importance of intersectoral, country specific, rather than interfirm, differences in technology as a motivation for trade. Specifically we assume that there are two countries, *A* and *B*, and a continuum of industrial sectors. Consumers in both countries have identical, Cobb-Douglas preferences. Firms in each of the industrial sectors of both countries have access to technologies to produce in their sector, either at home or abroad. Labor is the only productive input. Home production requires only domestic labor. Foreign production (FDI) requires both domestic and foreign labor, where the domestic labor can be interpreted as the (embodied) intangible assets, the country-specific knowledge, that gives the firm its productive edge. This assumption on firm/country specificity of FDI production technology is consistent with Cheng et al. (2005) and Lipsey (2002) as well as Markusen (1995). Firms are competitive. Comparative advantage and the equilibrium distribution of which firms produce what goods where is determined by tastes, technology, endowments, and competitive price setting.

We find that FDI flows from country *A* to country *B*, and vice versa. In their export versus FDI decision, firms take into consideration the advantages, such as local labor skills, transport costs and tariffs, and country-specific technology advantages, such as ownership advantages, proprietary information, patents, and embodied knowledge, of locating in rather than exporting to the host country. In equilibrium, Country *A* firms serve Country *B* markets in those industries in which Country *A* has a comparative advantage, where Country *A's* relatively more efficient industries export while its relatively less efficient industries serve the foreign market via FDI. So, for example, consider the US and suppose there are three sectors: high tech, medium tech and low tech, which can be thought of as sophisticated medical technology, automobiles, and clothing. Assume the US is most productive in high tech sectors, so it produces medical technology in the US and it exports that medical technology to its trading partners. Its productive efficiency allows it to absorb the transportation cost of exporting while still being able to supply the foreign market at a lower cost than can its potential foreign competitors. It is less productive in the auto industry, so it engages in FDI, taking its expertise abroad while availing of the lower foreign wages and avoiding transport costs and tariffs. Finally, it is least productive in clothing, an industry in which it does not produce and instead imports all clothing from its trading partners.

Our results are consistent with results of a variety of theoretical and empirical studies underpinned by a wide set of technology and industrial structure assumptions. For example, our results are consistent with the findings of Head and Ries (2003) in the context of a partial equilibrium, single industry, monopoly model. They are also consistent with recent empirical work. Yeaple (2003) provides evidence that the USA outward FDI occurs in those industries in which the USA has comparative advantages. Fosfuri and Motta (1999) illustrate how firms invest abroad to capture local advantages through geographical proximity (low transport costs). Makino et al. (2004) and Park (2003) provide evidence that Japanese FDI in developed countries is undertaken in those industries in which the Japanese have ownership (technological) advantage, and Driffield (1999) shows that, in the foreign-owned sector of the UK manufacturing industry, specific ownership advantage is an important component. Consistent with Head and Ries (2003), FDI is horizontal – it substitutes for exporting, so the same (single-product) firm will not both export and produce abroad via FDI. Factor endowments are important in that they affect relative wages, and so the range of goods each country produces. Effects of factor endowments on FDI are ambiguous and depend on the interaction of FDI and trade barriers, such as transportation costs and tariffs. Transportation costs do favor FDI at the expense of exports, but reduce both trade and investment. Finally, in contrast to the findings of the new trade theorists

(Helpman, 2006; Helpman et al., 2004), in our model, in a comparison of sectors, it is the *relatively* less productive firms that engage in FDI and the *relatively* more productive firms that export.

The paper proceeds as follows. In section II the model is developed and results on comparative advantage and the range of goods produced in each country are determined. Section III analyzes the general equilibrium. In section IV, comparative static exercises are conducted and the main findings of the paper are derived and discussed. Section V concludes.

II. THE MODEL

There are two countries, A and B with populations L_A and L_B, respectively. There is a continuum of industrial sectors in the world economy distributed on the interval [0, 1]. Markets are competitive. Individuals in both countries have identical preferences. Specifically, assume they share the same Cobb-Douglas tastes for the different types of goods produced in the different industries:

$$\log U = \int_0^1 \mu \log M(z)\, dz ,$$

where μ is a constant representing the expenditure share on industry z's manufactured goods and $M(z)$ represents the consumption of good z. The individual is subject to the budget constraint

$$Y \geq \int_0^1 P(z) M(z) dz ,$$

where $P(z)$ is the price of good z. This yields the familiar result that

$$M(z) = \mu \frac{Y}{P(z)} \tag{1}$$

and so we can define the economy's price index as

$$\log P = \int_0^1 \log P(z)\, dz ,$$

Producers

Assume that there is a continuum of sector specific firms in countries *A* and *B* each of which has access to technologies to produce in their industrial sector. Technologies are specific to sector, country of origin, and country in which production takes place. Labor is the only input, but the labor skills available to country *A* producers differ from those available to country *B* producers. In other words, for every particular industry *z*, say automobiles, all country *A*' firms in industry *z* share the same technology if they produce locally. The same assumption applies to country *B*'s firms. However, technology available in industry *z* in country A is not necessarily the same as that in country B. Firms participating in industry *z* are competitive. Hence, the most competitive remain in the market and all others exit. If we consider industry *z'*, other firms engage are competitive as well, and so on.

Assume that producers' technology is constant returns to scale, and hence their production function is linear. Therefore, let $a(z)$ denote the unit effective labor input requirement for a firm in country *A* to produce goods in industry *z*. Similarly, let $b(z)$ be the unit effective labor input requirement for a country *B* firm. In each country, there is a continuum of firms that can potentially serve either market. That is, a country *A* firm can produce in sector *z* at home using the country *A* technology, but it cannot produce at home or abroad using the country *B* technology. If it produces abroad, the technology it uses is specific to country *A* sector *z* firms producing in country *B* and requires both country *A* and country *B* labor inputs. When a firm undertakes FDI, managerial skills, patents, inputs and technology represent an important share of the investment that is paid at home country price levels (see Cheng et al., 2005).[1]

Prices

[1] In fact, Markusen et al. (2000), using data from UNCTAD, show that some home services, namely managerial services, engineering services, financial services, marketing and informational services, play an important role in FDI. They estimate that services could be up to 60% of a country's GDP, and when a firm conducts FDI both local labor and services are included in the total cost.

Consider a country A firm in industrial sector z and consider the decision of serving the domestic market and operating locally. Let W_A and W_B denote the wage in countries A and B respectively. In this case, the firm's operating profits will be $\pi_{AD} = P_{AD}Q_{AD} - W_A a(z)Q_{AD}$, where Q_{AD} denotes the output supplied to country A and produced in country A, P_{AD} denotes price and W_A denotes the wage paid to country A's workers. Equilibrium requires supply and demand of every good z to be equal. Since country A population is L_A, using the individual's demand (1) we obtain $Q_{AD}(z) = W_A L_A / P_{AD}(z)$. Plugging this term into π_{AD}, and considering that competition drives profits down to zero, so $\pi_{AD} = 0$ and rearranging we have

$$P_{AD}(z) = a(z)W_A . \qquad (2)$$

Domestic firms, however, may face competition from country B's firms, either because they decide to export the goods they produce to country A, or because they set up a subsidiary in country A. If a country B firm decides to compete through exports, it must ship goods to country A at a melting-iceberg transport cost $T > 1$. That is, for each unit of any good dispatched from one country to the other, only a fraction $1/T$ of the original unit actually arrives; the rest evaporates in transit. The firm's profit is $\pi_{AX} = P_{AX}\frac{Q_{AX}}{T} - W_B b(z)Q_{AX}$, where the subscript "$AX$" means that country A is served through exports. Considering that $Q_{AX} = \mu \frac{W_A}{P_{AX}(z)} L_A$ and that competition drives profits to zero, so $\pi_{AX} = 0$, and rearranging, we have that country B firms can lower the price to

$$P_{AX}(z) = b(z)W_A T . \qquad (3)$$

If instead, it decides to serve country A by setting up a subsidiary, that is, through foreign direct investment (FDI), the firm can use its own technology to produce in country A. However, differences between the two countries result in a cost function that incorporates features of both countries. On the one hand, it uses the labor skills, non-traded services and infrastructure available in country A, which are paid at local wage levels. On the other hand, it uses country *B* management, patents, and supervisors that receive country *B* wages. Therefore, we may assume that the cost function[2] of a country *B* firm undertaking FDI in country *A* can be written as $C(Q_{AI}) = a(z)^{1-\lambda} b(z)^{\lambda} W_A^{1-\lambda} W_B^{\lambda} Q_{AI}$, where the subscript "*AI*" means that country *A* is served through FDI. This is a standard Cobb-Douglas cost function that say that firms, when they undertake FDI, use both local and foreign technology, with both technologies weighted by the parameter λ. If λ is high, the firm is producing at a unit cost close to home production and its main benefits are savings in transport cost. Yet if λ is low, the firm's goods will be produced at efficiency levels close to those of country *A*. The operating profit for a country B firm that undertakes FDI in country A is therefore,

$$\pi_{AI} = P_{AI} Q_{AI} - C(Q_{AI})$$

Considering that $Q_{AI} = \mu \frac{W_A L_A}{P_{AI}}$, substituting $C(X_{AI})$ into π_{AI}, and considering that competition drives profits to zero and rearranging, we have that FDI firms can lower their price to

$$P_{AI}(z) = a(z)^{1-\lambda} b(z)^{\lambda} W_A^{1-\lambda} W_B^{\lambda} . \tag{4}$$

In order to facilitate the analysis, from now on we make several simplifying assumptions. First, since we are free to choose units of output in pounds, kilos, etc, we choose the appropriate unit of measurement for every good *z* to make $a(z) = 1$. This way *b*(*z*) represents not only the unit effective labor input requirement for a country *B* firm but also its unit labor requirement relative to country *A*. Second, we choose country *A* units of labor as numeraire, that is, we make $W_A = 1$. Third, we measure population in units of country A population size, $L_A = 1$, and let *L* denote country *B* population relative to country *A* population, $L = L_B / L_A$. Fourth, no restriction is imposed by sorting industries in such a way that

[2] The interpretation that we gives to the cost function is broader than in Cheng et al. (2005), as we include in the home component all kinds of services not only management services. Also, our cost function is Cobb-Douglas while theirs is linear.

$b'(z) > 0$, and fifth, no interesting insight is lost if we make μ = 1. Also, we denote $\omega = W_B / W_A$ so we can rewrite functions (2), (3) and (4) as

$$P_{AD}(z) = 1, \qquad P_{AX}(z) = b(z)\omega T \qquad \text{and} \qquad P_{AI}(z) = b(z)^{\lambda}\,\omega^{\lambda}. \tag{5}$$

Who Serves The Market?

What firms serve market *z*? Since the market structure is competitive, market *z* will be served by those firms offering the lowest price. First, consider Figure 1. Let b_A^* denote the unit effective labor input requirement for which competition forces both export and FDI prices to be equal for a country *B* firm. Let P_A^* and z_A^* denote their associated price and industry respectively, that is, $P_A^* = P_{AX}\left(b_A^*\right) = P_{AI}\left(b_A^*\right)$, and $b_A^* = b\left(z_A^*\right)$. In that industry, country *B* firms are indifferent between exporting to country *A* or setting up a subsidiary firm there. Hence, country *B* firms are in a better position to compete in country *A* markets through exports in the relatively more productive industries $\left[0, b_A^*\right)$ and through FDI in industries $\left(b_A^*, 1\right]$. The reason is that, when *b*(*z*) is low, country *B* firms are relatively more efficient in industry *z*. Since FDI requires the mixing of foreign and local skills and technology, country *B* firms will be able to produce at a lower cost at home than abroad. Therefore, country *B* firms are in a better position to compete through exports in those industries in which they are relatively more efficient. That advantage, however, is partially offset as transportation cost increases, and therefore, that advantage eventually disappears for the relatively less efficient industries, which consequently prefer to set up subsidiaries to save in transportation costs or to produce only for the home market.

Let us extend the analysis to include domestic firms. As Figure 2 shows, there are two possible equilibria. Figure 3 considers the case in which $P_A^* > 1$. In this case, foreign firms will be able to compete with domestic firms only through exports, as domestic firms are relatively efficient and thus foreign firms are able to compete only through exports. Figure 4 considers the case in which $P_A^* < 1$, that is, foreign firms are relatively efficient. In that case, country *A* firms produce domestically in those industries in which they are most efficient, $b > b^{**}$, and country *B* exports in their most efficient industries $b \in [0, b^*)$. However, there is a range of industries (b^*, b^{**}) in which the relative advantage of country *B* firms over country *A* firms is not high enough and so they set up subsidiaries in country *A* in order to save in transport costs and be in better position to compete by offering lower prices. This result differs from Helpman et al. (2004) which claim that only the most productive firms undertake FDI. The difference is due to Helpman et al.'s (2004) partial equilibrium analysis which, consider only one industry with a continuum of firms that differ in technology instead of a continuum of industries.

Let us inquire a bit more into those industries in which domestic firms are more competitive. If $P_A^* > 1$, foreign firms compete only through exports (Figure 2), and that occurs when $P_{AD}(z) > P_{AX}(z)$ if $1/\omega > Tb(z)$. Suppose now that $P_A^* < 1$ (Figure 3), then Country *A* firms and country *B* firms undertaking FDI set the same price in industry z_b, $P_{AD} = P_{AI}$, if

$$\omega = 1/b(z_b)$$

On the other hand, a country *B* firm is indifferent between exporting and undertaking FDI, $P_{AX} = P_{AI}$, if

$$\omega b(z_a) = 1/T^{1/(1-\lambda)}. \qquad (6)$$

Therefore, domestic firms can bid a lower price than foreign firms, whether they export or undertake FDI, for those industries z such that $z > z_b$, that is, in those industries in which it has a comparative advantage. For those industries, domestic firms serve the country *A* market. Likewise, foreign firms serve country *A* markets for those industries such that $z < z_b$. Nevertheless, they prefer to serve the market through FDI for those industries such that $z_a < z < z_b$, and through exports for those industries such that z < z_a.

Repeating the exercise, prices for country *B*, we have

$$P_{BD}(z) = b(z)\omega \qquad P_{BX}(z) = T \qquad \text{and} \qquad P_{BI}(z) = b(z)^{1-\lambda}\,\omega^{1-\lambda}\,. \tag{7}$$

Figures 5 and 6 show that similar results can be obtained for markets in country *B*. It is straightforward to obtain that, when firms undertake FDI, domestic firms will serve those markets in which z < z_b. Foreign firms serve through FDI those markets in which, $z_b < z < z_c$, and through exports those markets in which $z_c < z < 1$. That means that each country will be serving both countries in those industries in which it has comparative advantages. We also have that z_c is characterized by

$$\omega = T^{1/(1-\lambda)} / b(z_c).$$

Therefore, country *B* firms can set lower prices than foreign firms in the domestic market for industries z such that $z < z_b$, and country *A* firms are more competitive serving the foreign market through exports instead of FDI for industries $z > z_d$. The previous discussion, summarized in Figure 1, leads to the following

LEMMA 1: Let the wage ratio ω be given. Assume that both countries' technologies are advanced enough so they can undertake FDI.

(i) Country A has comparative advantages in industries [z_b, 1] and country B has comparative advantages in industries [0, z_b].

(ii) Firms serve both local and foreign markets in those industries in which their country has a comparative advantage.

(iii) Firms serve the foreign market through exports in those industries in which their efficiency is the highest, relative to foreign country firms, and serves it through FDI in those industries in which its efficiency is relatively low.

Lemma 1 states that each country produces in those industries in which it has a comparative advantage, and their firms undertake FDI only in those industries in which they already have a comparative advantage. Therefore, country *A* firms serve both countries in industries within the interval [z_b, 1], and country *B* firms serve both countries in industries in the interval [0, z_b]. In other words if, for example, the USA has a comparative advantage in software and Japan in domestic electronics (stereos, TVs, etc), the USA will serve both markets in software and Japan both markets in domestic electronics, but the USA firms will not undertake FDI in domestic electronics.

When λ is high (close to one), firms undertake foreign direct investment using technologies similar to host country firms. Country *A* firms only undertake FDI in those industries in the interval [z_b, z_c], and country *B* firms in those industries within the interval [z_a, z_b]. This means they would be undertaking FDI only in those industries in which they have comparative advantages but in the absence of FDI would be non-traded industries because of the high transport costs. Since we can expect, in general, that λ will be in the interval [0, 1], firms undertake FDI not only in those industries that otherwise would be non-traded but also in those that cluster around their marginal industries.

The decision about serving a foreign market through FDI or exports is based on their relative efficiency. The more efficient an industry is, the lower the price it can set to compete with other firms. Therefore, country *A* firms will serve country *B* markets through exports in industries [z_c, 1] and through FDI in industries [z_b, z_c]. The reason is that highly efficient firms can lower prices substantially and thus prefer to serve the foreign market by producing locally and paying transport costs. If efficiency is not that high, then firms prefer to save on transport costs and, thus, they can do better by setting up a subsidiary in the foreign country. This result is consistent with Head and Ries (2003) but differs from Helpman et al (2004) which claim that only the most productive firms undertake FDI. The difference is due to Helpman et al's (2004) partial equilibrium analysis in which, instead of competitive markets, they consider a monopolistically competitive model that concentrates on within sector differences in firm technologies while ignoring differences in technology between countries.

The Wage Equation

In equilibrium, demand and supply of labor must be equal. Since we are interested in analyzing the FDI vs. exports decision, consider the case in which both countries undertake FDI. Therefore, in country A, the supply of labor L_A must equal the summation of the labor demand of all domestic firms in all industries, plus the demand for country A workers of FDI firms in both countries, A and B, that is,

$$W_A L_A = (1 - z_a) W_A L_A + (1 - z_c) W_B L_B .$$

Dividing by W_A and remembering that $\omega = W_B / W_A$ and $L_A = 1$ by assumption, and rearranging, we have $\omega L = z_a / (1 - z_c)$. Since $P_{AX}(z_a) = P_{AI}(z_a)$ and $P_{BX}(z_c) = P_{BI}(z_c)$, from (5) and (7) we have that $b(z_a)\omega T = b(z_a)^{\lambda}\omega^{\lambda}$ and $T = b(z_c)^{1-\lambda}\omega^{1-\lambda}$, so $z_a = z_a(\omega, T)$ and $z_c = z_c(\omega, T)$. Therefore,

$$\omega L_B = D(\omega), \tag{8}$$

where $D(\omega) = \dfrac{z_a(\omega, T)}{1 - z_c(\omega, T)}$. Equation (8) determines the wage ratio, ω, and closes the system. A concern that remains is the existence of equilibrium. $D'(\omega) < 0$ is a sufficient condition to guarantee equilibrium. The following lemma establishes this.

LEMMA 2: The function $D(\omega)$ is negatively sloped.

Proof: See Appendix.

Since, by Lemma 2, $D(\omega)$ is negatively sloped, an equilibrium always exists.

LEMMA 3: An increase in ω makes all cutoff points z_a, z_b, z_c and z_d decrease.

Proof: See Appendix.

Lemma 3 states an increase country B wage relative to country A increases country A comparative advantages (z_a decreases) and decreases its imports from country B (z_c decreases). Similarly, country B comparative advantage is diminished (z_b decreases) and the amount of industries served by imports (z_d decreases) expands.

III. EQUILIBRIUM

From Figures 4 and 6, we have that $P_{AX}(z_a) = P_{AI}(z_a)$, $P_{AD}(z_b) = P_{AI}(z_b)$ and $P_{BX}(z_c) = P_{BI}(z_c)$. From (5) and (7), these equations can be rewritten as

$$b(z_a) = T^{-1/(1-\lambda)} / \omega, \tag{9}$$

$$b(z_b) = 1/\omega, \tag{10}$$

$$b(z_c) = T^{1/(1-\lambda)} / \omega. \tag{11}$$

Equations (8)-(11) constitute a system of four equations that determine equilibrium for z_a, z_b, z_c and ω. From lemma 3, we know $\partial z_a / \partial\omega < 0$, $\partial z_b / \partial\omega < 0$ and $\partial z_c / \partial\omega < 0$. Assuming that $\lambda T < 1$ in order to guarantee the existence of equilibrium, Figure 7 illustrates equilibrium. The top diagram in the Figure determines the equilibrium wage ω according to equation (8). Given ω, equations (8)-(11) represented in the left-lower part of the figure determine the technology for the cut-off industries $b_a = b(z_a)$, $b_b = b(z_b)$ and $b_c = b(z_c)$. Finally, the technology functions in the right-lower part of the figure determine the cutoff industries z_a, z_b and z_c.

IV. COMPARATIVE STATICS

A firm that produces domestically and at the same time serves the foreign market through exports will set higher prices abroad because the transport costs increase the unit cost. On the other hand, those industries that serve foreign countries through FDI differ in the weight of the home input and on the relative efficiency of their production technology. That is, a firm that serves the foreign market through FDI uses a home labor input, paid at home wages, which may differ from local wages. Yet, equilibrium prices depend on a number of parameters. Using (5), (7) and (8) we can obtain a number of important results

LEMMA 4: Suppose there is an increase in the relative size of country B, that is, in L_B, then

(i) Country *A* wages increase relative to country *B* wages.

(ii) Country *B* acquires a comparative advantage in industries and country *A* loses comparative advantage.

(iii) The range of industries served by country *A* (*B*) firms decreases (increases).

(iv) The range of industries served by country *A* (*B*) firms through exports decreases (increases).

(v) The effect on the range of industries undertaking FDI in both countries is ambiguous and it depends on the technology functions $b(z)$.

Proof: See Appendix.

An increase in country *B* relative labor force results in an excess supply of labor. On the other hand, the greater population in country *B* increases the demand for country *A* goods, and thus creates an excess demand for labor in country *A*. Both effects result in lower relative wages in country *B*. The lower wage ratio ω makes country *B* firms able to compete at lower prices, acquiring comparative advantages in marginal industries, and thus, an increase in the range of industries that country *B* firms serve in both domestic and foreign markets. Using similar reasoning, country *A* firms will serve both markets in fewer industries.

The higher population in country *B* results also in a temporary trade deficit, or equivalently a temporary trade surplus in country *A*, which is offset as country *B* acquires comparative advantages in marginal industries and so increases their exports to country *A*. Also, country *B* firms will be able to compete and thus control markets in marginal industries that were previously served by country *A* firms through FDI. On the other hand, the lower relative wage in country *B* makes it profitable to undertake FDI projects in industries that previously served the foreign market through exports.

Let us inquire now into the effect of transport costs on the general equilibrium. Given the wage ratio, ω, it is apparent from (5) and (6) that an increase in transport costs *T* makes z_a decrease and z_c increase, but has no effect on z_b. This means that as transport costs increase, given the wage ratio, ω, international trade diminishes as fewer industries in both countries will be willing to serve foreign markets through exports. However, those markets will not be served by domestic firms but still by foreign firms through FDI. In other words, FDI activity grows at the expense of exports.

So far, we have assumed that the wage ratio is given. Yet, as firms switch from exports to FDI, labor demand is affected and so are the wage rate and prices in both countries. An increase in the wage ratio enhances the effect on country *A* exports but offsets the effect on country *B* exports, and vice-versa. However, since transport costs affect both countries in the same way, the net effect on the wage ratio is ambiguous and it depends on the form of function $b(z)$.

To analyze the effect of a change in technology, consider Figure 8. The initial equilibrium wage is given by ω_0 and industry, z_i for $i = a$, b or c. A general improvement in technology makes the unit effective labor input requirement $b(z)$ for each industry in country *B* decrease, which makes the curve *b* shift out to *b'*. The right-lower diagram in Figure 8 illustrates this effect, and the curve b_i shifts downward for every industry z_i. Equations (9)-(11) associate lower input requirement industries with higher technology and higher wages (left-lower diagram in Figure 8). Taking derivatives with respect to *b* in (8) we find,

$$\frac{dD}{db} = \frac{\frac{dz_a}{db}(1-z_c) + z_a \frac{dz_c}{db}}{(1-z_c)^2} > 0$$

Since $\frac{dz_a}{db}$ and $\frac{dz_c}{db}$ are positive, this derivative is positive, and the decrease in *b* causes an upward shift in $D(\omega)$ in the top diagram in Figure 8, raising salaries in country B. In summary, a technological improvement in country *B* causes an increase in relative wages in every industry in country *B*. How is trade affected by that? By assumption, the relationship between z_i (for $i = a$, b or c) and b is increasing, and lower b is associated with lower z_i. Therefore, an improvement in technology will cause z_i to decrease, for $i = a$, b or c. Therefore, country *B* will serve fewer industries overall and country *A* will serve more industries through exports. The effect on the amount of industries served by country *A* through FDI is undefined. The following lemma summarize these results.

LEMMA 5: Suppose that country *B* uniformly improves its technological efficiency in every industry relative to country *A*, then

(i) Country *B* wages relative to country *A* wages increases.

(ii) Country *A* expands its range of industries in which it has comparative advantage.

(iii) The range of industries served through imports decreases in country *A* and increases in country *B*.

z_i^0

(iv) The range of industries served through FDI changes in an undefined way, each country will be serving through FDI those marginal industries in which they are more efficient.

<u>Proof</u>: See Appendix.

Suppose now that country *A* levies a uniform tariff on imports at a rate τ. From equation (5), the price of imported goods become

$$P_{AX}(z) = b(z)\omega T(1+\tau).$$

and (9) becomes

$$b(z_a)^{1-\lambda}\omega^{1-\lambda}T(1+\tau) = 1$$

Therefore, a uniform increase in tariff on imports τ will make z_a decrease. In other words, by making imported goods more expensive in country *B*, foreign firms tend to serve country *B's* marginal markets through FDI instead of exports. In equilibrium, fewer firms serve country *B* through exports while more serve it through FDI. Notice, however, that neither country acquires a comparative advantage in new industries, but simply switches the way they serve the foreign market.

V. CONCLUSION

This paper develops a Ricardian model of trade and investment with a continuum of goods in which firms decide whether or not to serve foreign markets, and if they decide to do so, whether to serve it through exports or foreign direct investment. The model contributes to the literature in that it approaches the issue within a general equilibrium framework in which local and foreign firms compete in competitive markets. Results obtained are consistent with some empirical findings in the literature [see, for example, Markusen 1995]. Firms serve both markets, local and foreign, only in those industries in which they have a comparative advantage. In their investment decision, and among the industries in which they have a comparative advantage, firms choose to serve foreign markets through exports in those industries in which they are relatively more efficient, and through foreign direct investment in those others in which they are relatively less efficient. As in Helpman et al. (2004), this paper concludes that, within each sector, the most productive firms engage in FDI. However, it complements Helpman et al. (2004)'s approach in that it considers cross country within-sector heterogeneity (although not within country, within sector heterogeneity as Helpman does) while focusing on heterogeneity across industries within and across countries, which is what makes the paper Ricardian.

In the comparative static exercise, we find that an increase in country *A's* relative size makes its relative wage decrease and extends its comparative advantages to a broader range of industries, which will be served through FDI. An interesting effect is that of a change in technology. An overall improvement in country *B's* technological efficiency makes its relative wage increase, but decreases its comparative advantages, and shrink the range of industries served through exports. The model clearly illustrates how the industrial organization of international markets affects the structure of international trade and firms' investment decisions in a broader general equilibrium framework.

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APPENDIX:

Proof of Lemma 2 and 3:

Cutoff points z_a, z_b and z_c are determined by

$$P_{AX}(z_a) = P_{AI}(z_a), \qquad P_{AD}(z_b) = P_{AI}(z_b) \qquad \text{and} \qquad P_{BX}(z_c) = P_{BI}(z_c).$$

From (5) and (7) these equations can be rewritten as

(A.1) $\quad b(z_a) = T^{-1/(1-\lambda)} / \omega$,

(A.2) $\quad b(z_b) = 1/\omega$ and

(A.3) $\quad b(z_c) = T^{1/(1-\lambda)} / \omega$

Equilibrium is determined by equations (A.1)-(A.3) and (8), which we rewrite here as

(A.5) $\quad \omega L_B = D(\omega) = \dfrac{z_a(\omega)}{1 - z_c(\omega)}$

It is apparent that the derivatives with respect to ω in (A.1), (A.2) and (A.3) are all negative,

(A.6) $\quad \dfrac{\partial b(z_a)}{\partial \omega} = -T^{-1/(1-\lambda)} \omega^{-2} < 0, \qquad \dfrac{\partial b(z_b)}{\partial \omega} = -\omega^{-2}, \qquad \dfrac{\partial b(z_a)}{\partial \omega} = -T^{1/(1-\lambda)} \omega^{-2} < 0.$

And therefore, since $b'(z) > 0$,

$$\frac{\partial z_a}{\partial \omega} < 0, \qquad \frac{\partial z_c}{\partial \omega} < 0, \qquad \text{and} \qquad \frac{\partial z_b}{\partial \omega} < 0.$$

Consider now (8),

$$D'(\omega) = \frac{z_a'(\omega)(1 - z_c(\omega)) + z_a(\omega) z_c'(\omega)}{(1 - z_c)^2} < 0$$

That is, $D(\omega)$ is a decreasing function of ω.

Proof of Lemma 4

Using (8), we define $F(\omega, L_B) = \omega L_B - D(\omega)$. From the theorem of the implicit function,

$$\frac{\partial \omega}{\partial L} = -\frac{\partial F / \partial L_B}{\partial F / \partial \omega} = \frac{-\omega}{L_B - \partial D / \partial \omega}$$

The numerator is clearly negative. On the other hand, from lemma 2, $\partial D / \partial \omega < 0$ and so the denominator is positive. Therefore, $\partial \omega / \partial L < 0$. This proves (i).

From (4), $\frac{\partial P_{AI}}{\partial \omega} = \lambda b(z)^{\lambda} \omega^{\lambda - 1} > 0$. Since ω decreases, P_{AI} also decreases and so z_a increases. This means that country *A* comparative advantages shrinks. Similarly, country *B*'s comparative advantages are now expanded. We also have that the range of industries served by local firms decrease in country *A* but increases in country *B*. This proves (ii) and (iii).

We have that

$$\frac{dz_a}{dL_B} = \frac{\partial z_a}{\partial \omega} \frac{\partial \omega}{\partial L_B}, \qquad \text{and} \qquad \frac{dz_c}{dL_B} = \frac{\partial z_c}{\partial \omega} \frac{\partial \omega}{\partial L_B}$$

Yet, $\frac{\partial \omega}{\partial L_B}$ is negative, and $\frac{\partial z_a}{\partial \omega} < 0$, $\frac{\partial z_c}{\partial \omega} < 0$. Therefore, both dz_a / dL_B and dz_c / dL_B are positive. Thus, an increase in country B population, lower its salary and increase the range of industries it serves to country A as well as the range of industries it serves through exports.

$$\frac{dz_c}{dL_B} - \frac{dz_a}{dL_B} = \left(\frac{\partial z_c}{\partial \omega} - \frac{\partial z_a}{\partial \omega} \right) \frac{\partial \omega}{\partial L_B},$$

So the sign is determined by $\left(\frac{\partial z_c}{\partial \omega} - \frac{\partial z_a}{\partial \omega} \right)$ yet, this is determined by the shape of $b(z$. Therefore, the differences $(z_c - z_b)$ and $(z_b - z_a)$ are ambiguous. This proves (iv) and (v).

Q.E.D.

FIGURE 1

EXPORTS VS. FDI

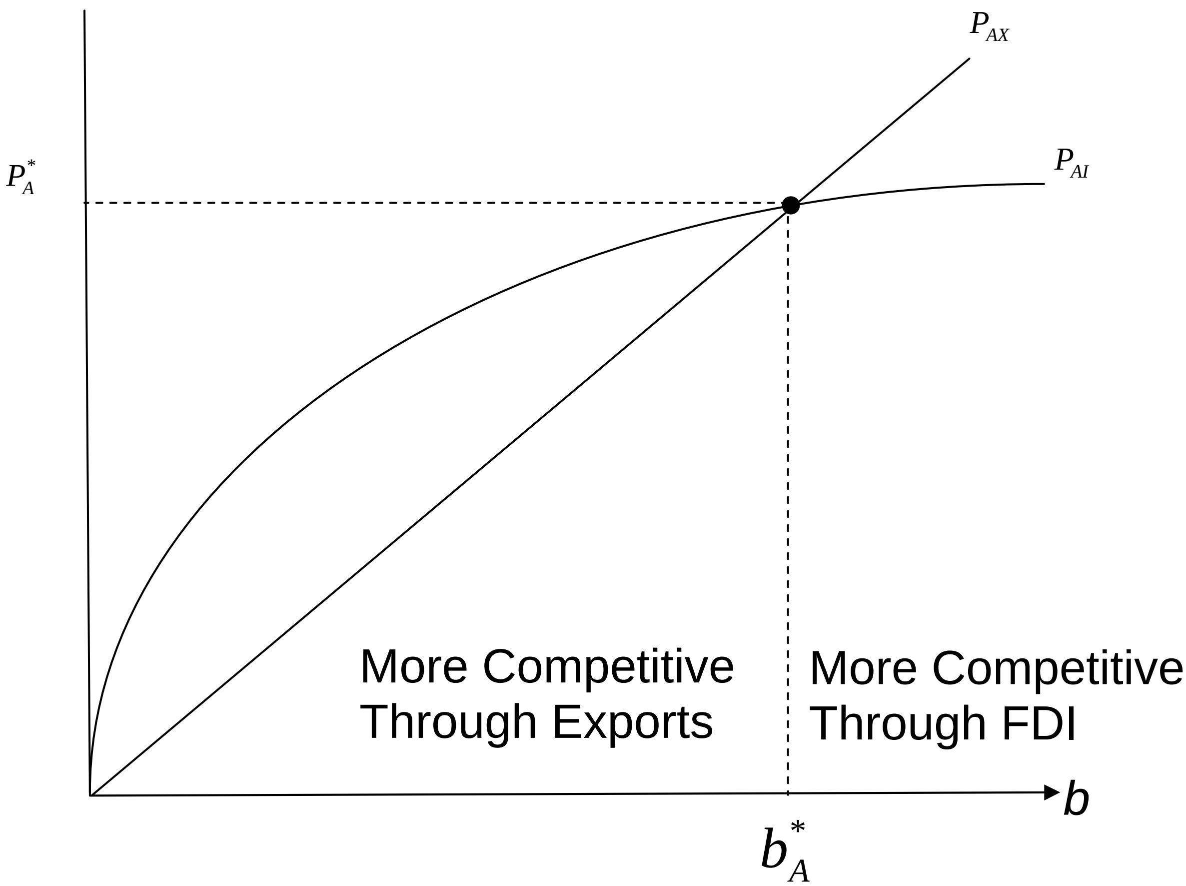

FIGURE 2

CHANGE IN FDI COST

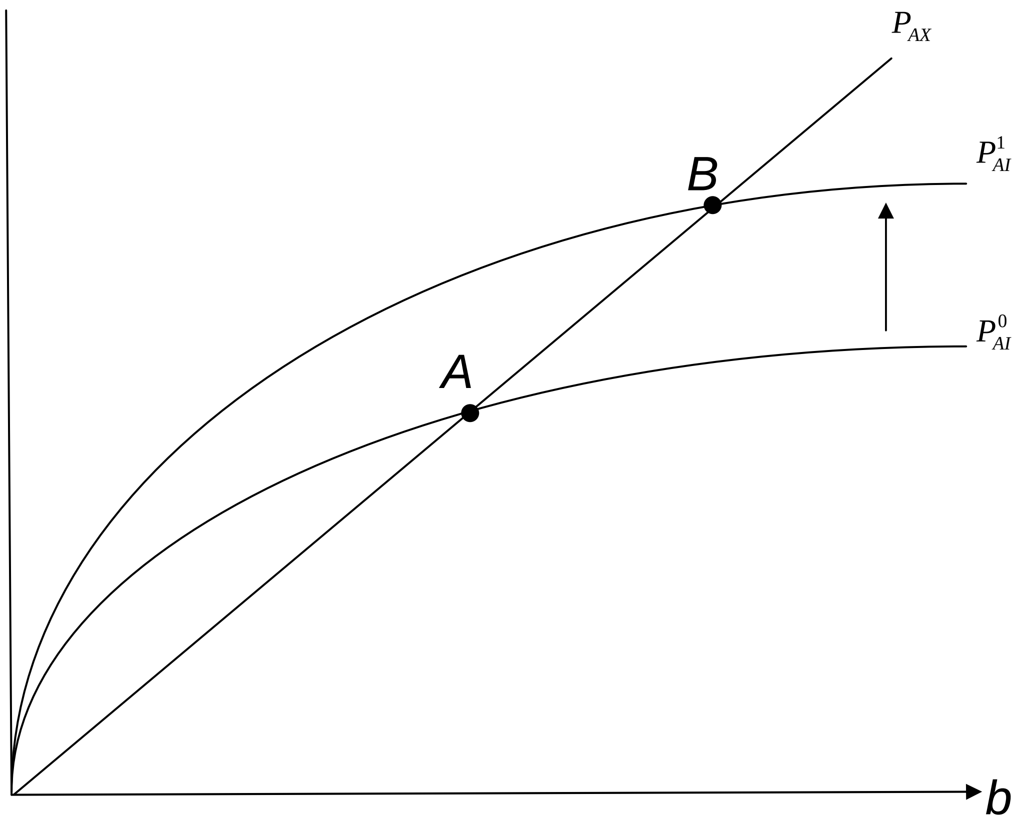

FIGURE 3

COUNTRY A DECISIONS – NO FDI

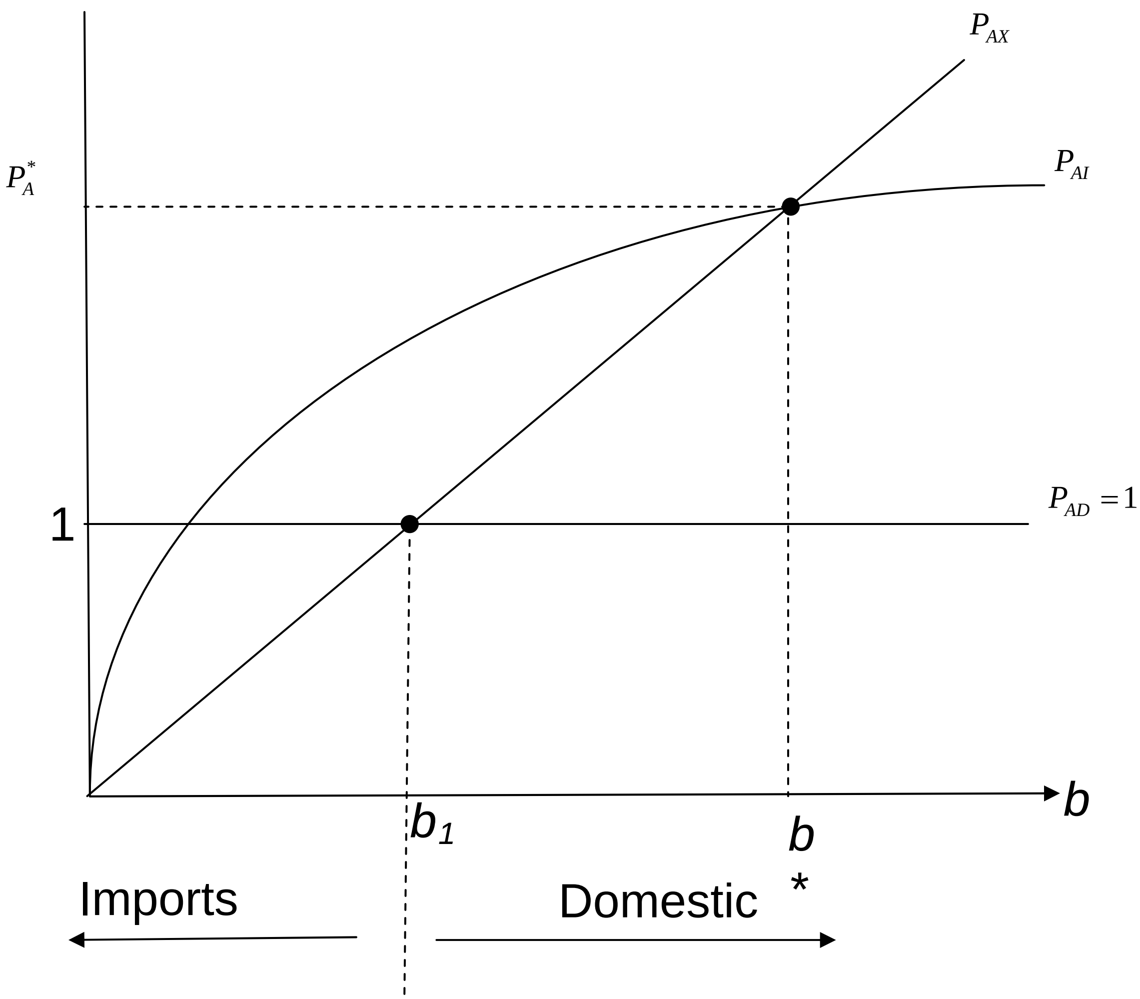

FIGURE 4

COUNTRY A DECISIONS – FDI

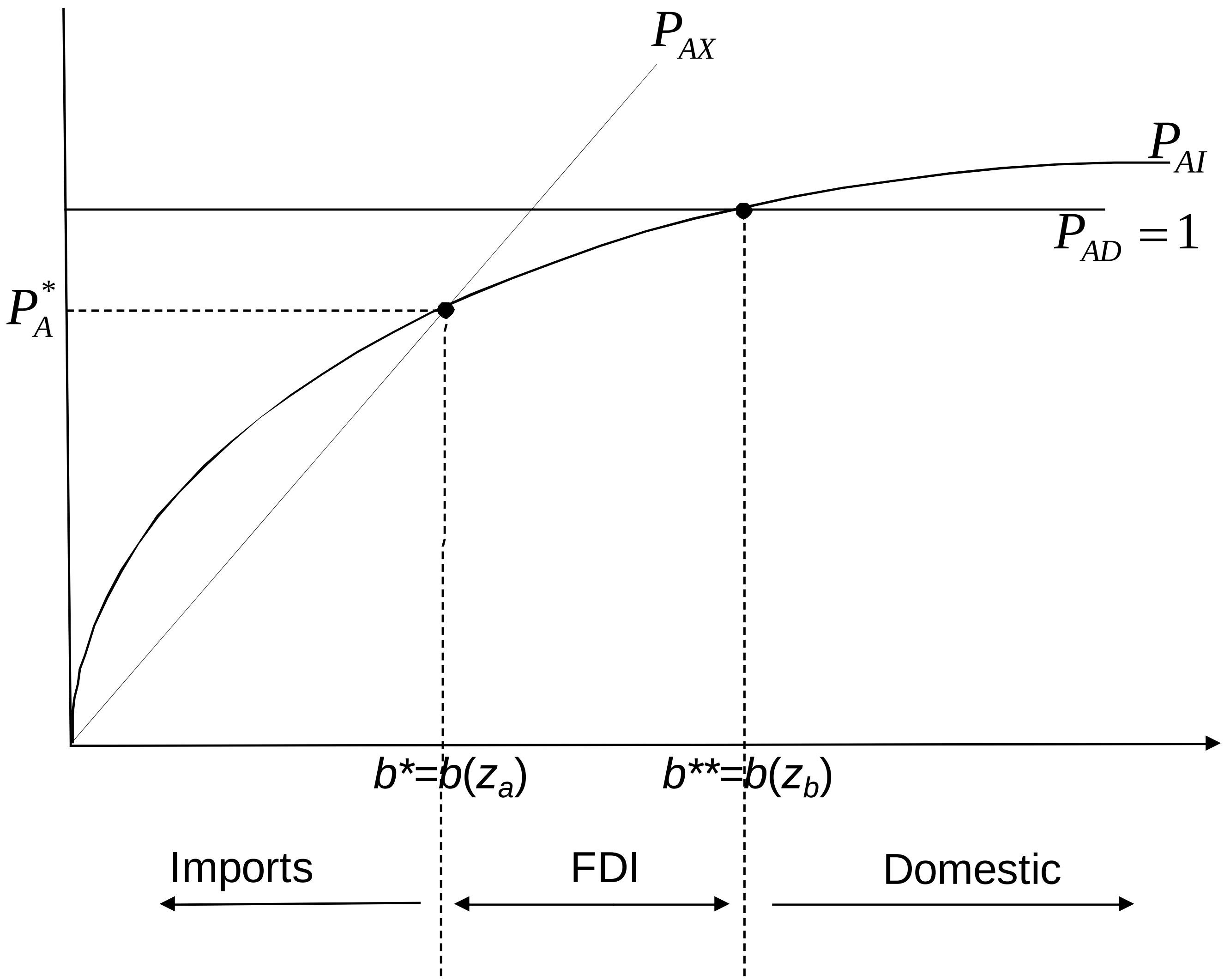

FIGURE 5

COUNTRY B DECISIONS – NO FDI

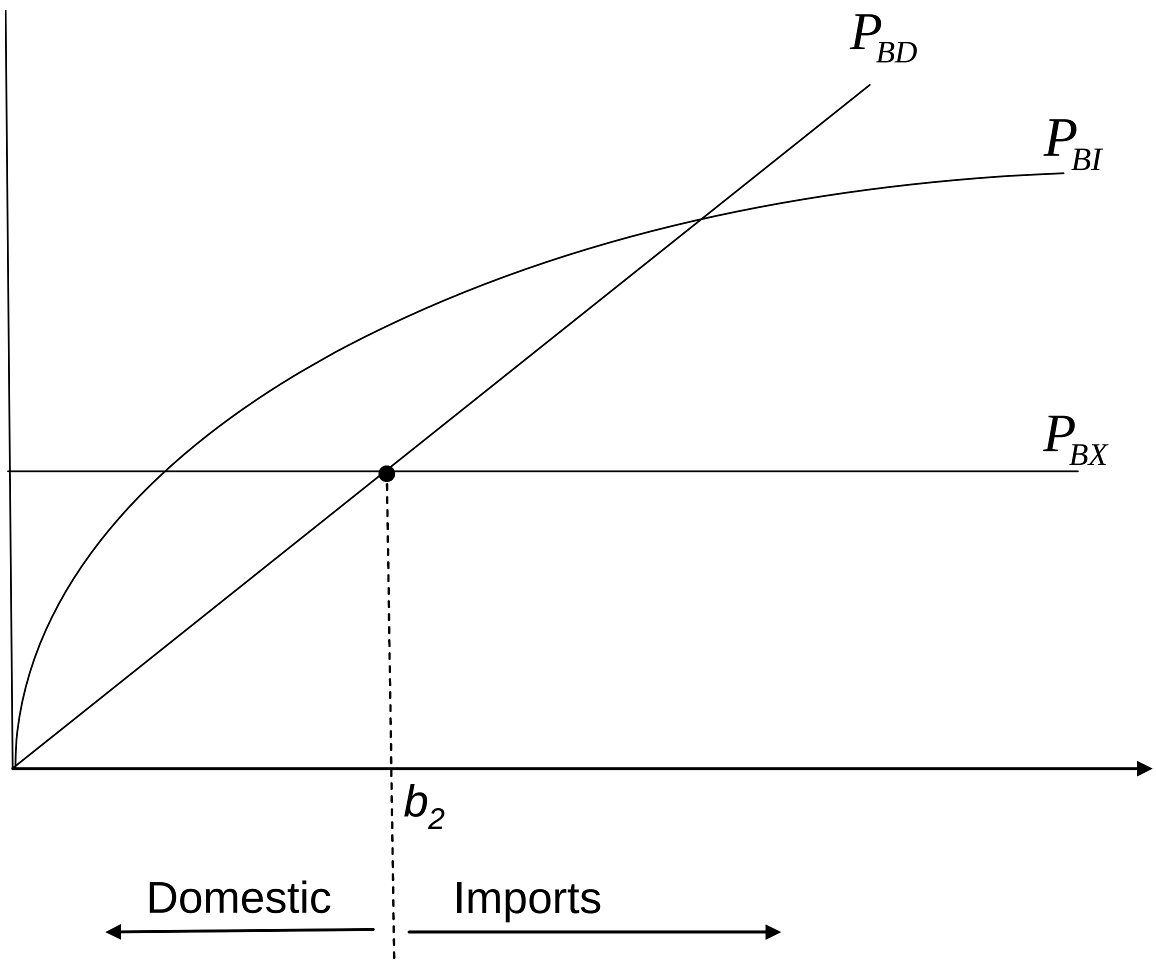

FIGURE 6

COUNTRY B DECISIONS –FDI

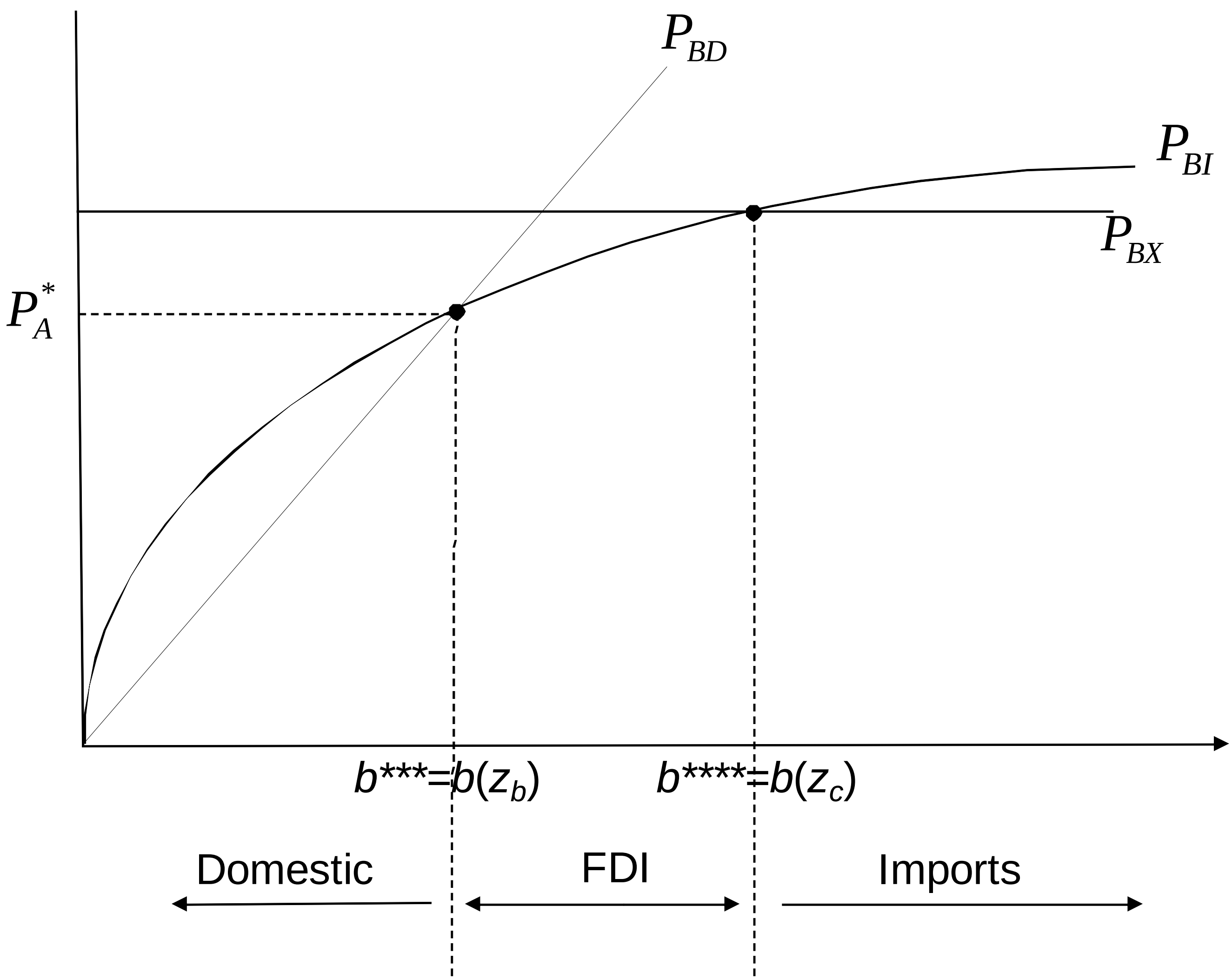

FIGURE 7

EQUILIBRIUM

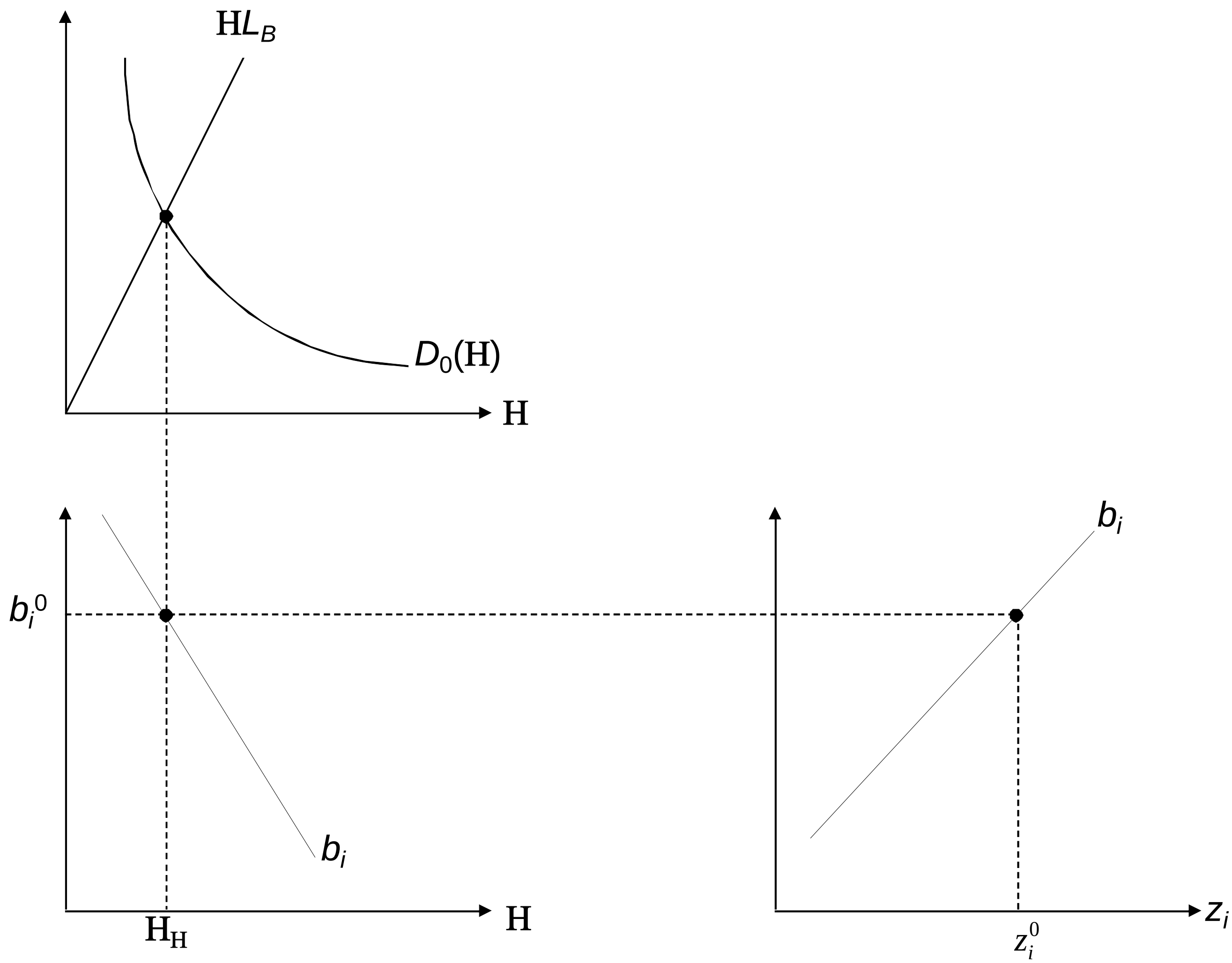

FIGURE 8

CHANGE IN TECHNOLOGY