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Home Market Effects Revisited

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Technology Advantage and Trade: Home Market Effects Revisited

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Abstract

According to conventional home market effects, free trade tends to shrink the market share for the smaller economy in the differentiated manufacturing goods, and in the extreme, leads to a complete hollowing out of the industry. In departing from the original Helpman-Krugman modeling assumptions behind the home market effects, we introduce technology differences between trading partners and prove that the home market effects will be offset and will even reverse if the small economy has better technology than the other country. We also prove that even with identical country size, the intra-industry trade addressed in the existing literature may not occur; it will occur only if the technology differential lies within a certain range that is positively affected by the level of transport cost.

Classification : F12
Key Words : Home market Effects, Country Size, Technology Differential

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1 Introduction

This paper aims at exploring the effect of technology advantage on the conventional home market effects, initially raised by Krugman (1979). In a monopolistic competition model, Krugman (1979, 1980) and Helpman and Krugman (1985) illustrate the home market effects, that is, a country with larger consumers will run a trade surplus in the differentiated products characterized by scale economies. The illustration of the home market effects in these papers relies on a specific market structure and functional form assumptions, especially on Dixit and Stiglitz's (1977) preferences and 'iceberg' transport costs. Thus, a further development in the literature has been to examine the robustness of the home market effects under different modeling assumptions.

In a model of monopolistic-competition with many industries, Hanson and Xiang (2004) prove that higher transport costs and more differentiated products tend to have more intensive home market effects. Davis (1998) illustrates that if the homogeneous good and differentiated goods face identical transport costs, then the home market effect vanishes. Behrens (2005) shows that the existence of non-traded goods may also offset the home market effect. Head, et al. (2002) find the reverse of a home market effect exist in a Cournot-competition model, in which varieties are linked to nations (rather than firms). This result is consistent with those in Head and Ries (2001) who consider a model featuring perfect competition and national product differentiation. A similar reverse home market effect is also found in a 'reciprocal-dumping' model by Feenstra, et al. (2001) who also consider varieties tied to nations. Yu (2005) shows that if the consumer's preference follows the form of a constant elasticity of substitution between the homogeneous and differentiated goods, then the reverse home market effect may occur depending on the level of elasticity. More specifically, if the elasticity of substitution is less than one, then the home market effects will reverse.

The existing literature on home market effects ignores the difference in technology between countries. To focus on the role of a technology advantage for offsetting or even reversing the home market effects, we will employ the same Helpman-Krugman-type two-sector model (one homogeneous good with no transport costs, and the other differentiated good with a positive transport cost) in the literature, but allow for technology differences between countries in the differentiated sector. We prove that the home market effects can be offset by the technology advantage of the smaller trading partner. In the extreme, a small but technologically better country can have trade-induced expansion rather than a reduction in its manufacturing sector. On the contrary, a big but technologically poorer country may end in decreasing rather than increasing its share in the differentiated manufacturing sector. In other words, the technology difference may lead to a home market effect reversal, if the technology difference is large enough. In addition, we also prove that the higher the transport costs, the less likely it is that a reverse home market effect will occur. The implications of the results for the core-periphery pattern induced by free trade are also analyzed. We show that the technology advantage can help prevent a small country from being peripherized in the differentiated manufacturing industry. We also prove that, even with identical country size, the intra-industry trade addressed in the existing literature may not occur; it occurs only if the technology differential between countries is within a certain range, which is positively affected by the level of transport cost.

The remainder of this paper is organized as follow. Section 2 establishes the theoretical model with cross-country technological difference, and solves for the equilibrium under both autarky and free trade. Section 3 shows that the conventional home market effects will be revised due to the technology differences. Section 4 concludes the paper.

2 The model

Suppose that the economy comprises two countries, home and foreign (denoted by an asterisk (*)), and that they are similar in regard to the consumer's preferences but not necessarily in their production technologies and size. There is only one factor of production, labor, and thus the relative country size is measured by the labor force. Let L denote the size of the world's total labor force, of which γL $(0 < \gamma < 1)$ belongs to the home country and $(1-\gamma)L$ belongs to the foreign. That is, γ denotes the relative home country size. As usual, we assume that there are only two sectors: one a competitive sector which produces a homogeneous goods (Y), and the other a monopolistical competition sector which produces a large unmber of varieties of a firm-specific differentiated product (X). The homogeneous good, which will be taken as the numeraire, is produced under constant returns to scale technology.

The central assumption is that there is a positive (but not prohibitive) transport cost for the differentiated product under free trade. More specifically, for the differentiated product, the international shipment incurs a "iceberg" effect of transport costs, that is, for t $(t > 1)$ units of the goods shipped, only one unit arrives. Thus, the domestic price of the imported differentiated product will be tp^*, provided that p^* is the producer's price for the foreign product. On the other hand, the homogeneous good is assumed to be costlessly to trade, and both countries produce it after trade; with identical technology in this sector, this assumption implies that the wage rates are equal between the countries.

Furthermore, we assume that all consumers share the same Cobb-Douglas preferences, which are represented by the utility function shown below:

$$U = C_Y^{1-s} C_X^{s}, \quad 0 < s < 1, \tag{1}$$

where C_Y is the consumption level of the homogeneous good, C_X is the quantity index of the differentiated products consumed, and s is the share of spending devoted to the differentiated products. The quantity index takes the well-known form

$$C_X = \left(\sum_{i=1}^{n} c_i^{\theta} + \sum_{i^*=1}^{n^*} c_i'^{\theta} \right)^{1/\theta}, \quad 0 < \theta < 1, \tag{2}$$

where n (n^*) is the number of products produced in the home (foreign) country, c_i (c_i') is the quantity of the home (foreign) product i consumed by the home consumers, and $1/(1-\theta)$ is the elasticity of substitution between every pair of differentiated products.

Solving the consumer's utility maximization problem yields the following domestic demand function (c_i) for each unit of home product i.

$$c_i = p_i^{\frac{1}{\theta-1}} P^{\frac{\theta}{1-\theta}} \, sw\gamma L, \tag{3}$$

where p_i denotes the price of home product i , P denotes the price index for the differentiated goods to be shown later, w denotes the nominal wage, and thus $w\gamma L$ represents the income level for the home country. Similarly, the derived demand for foreign product i on the part of home consumers (c_i') is

$$c_i' = (tp_i^*)^{\frac{1}{\theta-1}} P^{\frac{\theta}{1-\theta}} \, tsw\gamma L. \tag{4}$$

Correspondingly, we have the foreign consumers' demand for the domestic goods, c_i^*, and for the imported goods, $c_i'^*$, as follow:

$$c_i^* = p_i^{*\frac{1}{\theta-1}} P^{*\frac{\theta}{1-\theta}} \, sw^*(1-\gamma)L, \tag{3'}$$

$$c_i'^* = (tp_i)^{\frac{1}{\theta-1}} P^{*\frac{\theta}{1-\theta}} \, tsw^*(1-\gamma)L. \tag{4'}$$

The price index for the differentiated products that is dual to the subutility is represented by

$$P = \left[\sum_{i=1}^{n} p_i^{\frac{\theta}{\theta-1}} + \sum_{i^*=1}^{n^*} (tp_i^*)^{\frac{\theta}{\theta-1}} \right]^{\frac{\theta-1}{\theta}}, \quad P^* = \left[\sum_{i=1}^{n} (tp_i)^{\frac{\theta}{\theta-1}} + \sum_{i^*=1}^{n^*} (p_i^*)^{\frac{\theta}{\theta-1}} \right]^{\frac{\theta-1}{\theta}}. \tag{5}$$

On the other hand, the production technology in the homogenous sector is such that one unit of output requires one unit of labor input. Apart from the traditional setup, we assume that there is a cross-country technological heterogeneity in the monopolistically competitive sector. Let the amount of labor required to produce the quantity x_i of product i be given by

$$l_i = \alpha + \beta x_i, \quad l_i^* = \alpha^* + \beta^* x_i^*, \tag{6}$$

where $\alpha > 0$ ($\alpha^* > 0$) is the fixed labor requirement and $\beta > 0$ ($\beta^* > 0$) is the marginal labor requirement for the home (foreign) firm. Clearly, the technology difference is represented by different coefficients of the labor requirements.

For ease of comparison, Section 2.1 starts with the autarky equilibrium. Then Section 2.2 analyzes the equilibrium under free trade.

2.1 Autarky equilibrium

For simplicity, we start with the equilibrium under the state of autarky, i.e., $c_i^{\prime} = 0$. Under the assumption of monopolistic competition, each firm will take the price index P as given, and two equilibrium conditions should hold, that is, profit maximization and the zero-profit condition. Note that the producer of a differentiated product has to commit α units of labor as the fixed cost and β units of labor as the constant marginal input. The profit maximization implies that the marginal revenue should be equal to marginal cost, that is,

$$p_i = \frac{\beta w}{\theta}, \quad p_i^* = \frac{\beta^* w^*}{\theta}. \tag{7}$$

The zero profit condition requires that the average cost equal the unit price of p_i. By means of the zero profit condition and equation (7), we can derive the equilibrium quantity of production for the home (foreign) firm x_i (x_i^*) as follow:

$$x_i = \frac{\theta}{1-\theta}\frac{\alpha}{\beta}, \quad x_i^* = \frac{\theta}{1-\theta}\frac{\alpha^*}{\beta^*}. \tag{8}$$

For simplification, we suppress subscript i in what followings.

The full employment condition requires that the labor supply equal the labor demand, as in the home (foreign) differentiated sector.

$$s\gamma L = n[\alpha + \beta x], \quad s(1-\gamma)L = n^*[\alpha^* + \beta^* x^*]. \tag{9}$$

Making use of the equations (8) and (9) yields

$$n^A = \frac{(1-\theta)\, sL}{\alpha}\gamma, \quad n^{A*} = \frac{(1-\theta)\, sL}{\alpha^*}(1-\gamma). \tag{10}$$

Obviously, the superscript A is denote "Autarky".

2.2 Free trade equilibrium

Suppose now that the two countries open their goods markets to each other. The market clearing condition for each of the differentiated products of the home firms, say, x, requires that $x = c + c'^*$. In other words, total supply x should equal the sum of home and foreign demand, c and c'^*, respectively. By making use of equations (3), (4′) and (8), the market clearing condition for each home good can be rewritten as:

$$\begin{aligned} \frac{\theta}{(1-\theta)}\frac{\alpha}{\beta} &= p^{\frac{1}{\theta-1}} P^{\frac{\theta}{1-\theta}}\, sw\gamma L + (tp)^{\frac{1}{\theta-1}} P^{*\frac{\theta}{1-\theta}}\, tsw^*(1-\gamma)L \\ &= \frac{p^{\frac{1}{\theta-1}}\, sw\gamma L}{\phi_1} + \frac{\tau p^{\frac{1}{\theta-1}}\, sw^*(1-\gamma)L}{\phi_2}, \end{aligned} \tag{11}$$

in which we have defined ϕ_1, ϕ_2 and τ as follows:

$$\phi_1 \equiv np^{\frac{\theta}{\theta-1}} + n^*\tau p^{*\frac{\theta}{\theta-1}} \text{ and } \phi_2 \equiv n\tau p^{\frac{\theta}{\theta-1}} + n^* p^{*\frac{\theta}{\theta-1}}, \tag{12}$$

$$\tau \equiv t^{\frac{\theta}{\theta-1}}, \quad 0 < \tau < 1.$$

Correspondingly, we have the market clearing condition for each foreign good, $x^* = c' + c^*$, and by making use of equations (3′), (4) and (8) we obtain:

$$\begin{aligned}\frac{\theta}{(1-\theta)}\frac{\alpha^*}{\beta^*} &= (tp^*)^{\frac{1}{\theta-1}} P^{\frac{\theta}{1-\theta}}\ tsw\gamma L + (p^*)^{\frac{1}{\theta-1}} P^{*\frac{\theta}{1-\theta}}\ sw^*(1-\gamma)L \\ &= \frac{p^{*\frac{1}{\theta-1}}\ \tau sw\gamma L}{\phi_1} + \frac{p^{*\frac{1}{\theta-1}}\ sw^*(1-\gamma)L}{\phi_2}. \qquad (13)\end{aligned}$$

Note that as the homogeneous product sector remains active in both countries, the identical technology and costless trade in Y ensure an identical wage rate between the home and foreign countries. In other words, the home wage rate w should be equal to the foreign wage rate w^*, i.e., $w = w^*$. By making use of $w^*/w = 1$, we can solve equations (11) and (13) to obtain (see Appendix 1 for the mathematical derivation):

$$n^T = \frac{(1-\theta)sL}{\alpha}\left[\frac{\gamma}{1-\tau\Phi} - \frac{\tau(1-\gamma)}{\Phi-\tau}\right], \qquad (14)$$

$$n^{T*} = \frac{(1-\theta)sL}{\alpha^*}\Phi\left[\frac{1-\gamma}{\Phi-\tau} - \frac{\tau\gamma}{1-\tau\Phi}\right], \qquad (15)$$

where the superscript T denotes the state of free trade equilibrium, and

$$\Phi \equiv \frac{\alpha^*}{\alpha}\left(\frac{\beta^*}{\beta}\right)^{\frac{\theta}{1-\theta}}, \qquad (16)$$

represents the technology difference between the countries. As we can see from equation (16), the factors affecting the technology differential include the ratio of the fixed labor requirement (α^*/α) and the ratio of the marginal labor requirement (β^*/β). Furthermore, higher values of α^* and β^* and/or lower values of α and β corresponding to a higher Φ indicate higher technology advantage for the home country, or equivalently a technology disadvantage for the foreign country.

3 Home market effects revisited

The conventional home market effects, as derived by Krugman (1979, 1980), Helpman and Krugman (1985), etc. state that a large country tends to have a more-than-proportional share of differentiated industries, since with increasing returns, transport costs provide an advantage for firms located in a larger market. However, as will be elaborated below, the technology advantage can offset or even reverse the home market effects.

To analyze the role of technology difference for the home market effects, we specifically have to compare the number of firms both before and after the free trade takes place. That is, $n^T - n^A$ for the home country, and $n^{T*} - n^{A*}$ for the foreign country. By using equations (14) and (10), the trade-induced change in the number of home firms can be derived as

$$n^T - n^A = \frac{(1-\theta)sL}{\alpha}\left[\frac{\tau\Phi\gamma}{1-\tau\Phi} - \frac{\tau(1-\gamma)}{\Phi-\tau}\right]. \tag{17}$$

Similarly, for the foreign country using equations (15) and (10) yields

$$n^{T*} - n^{A*} = \frac{(1-\theta)sL}{\alpha^*}\left[\frac{\tau(1-\gamma)}{\Phi-\tau} - \frac{\tau\Phi\gamma}{1-\tau\Phi}\right]. \tag{18}$$

As already pointed out in the literature, the factors affecting the home market effects include both transport costs and country size. However, according to equations (17) and (18), we can see that, in addition to the transport cost τ and relative country size γ, the technology differential Φ is also an important factor affecting the home market effects.

For simplicity, we will rely mainly on a geometrical approach to conduct our analysis. For this purpose, the strategy used to analyze the trade-induced change in the number of firms, i.e. $n^T - n^A$, is as follows:

In the first step, we use equation (10) to determine the geometrical relationship between the country size (γ) and the number of firms under autarky (n^A), denoted as Line-n^A.

Secondly, we use equation (14) to depict the geometrical relationship between the country size (γ) and the number of firms under free trade (n^T), denoted as Line-n^T. Then, in the final step, we compare on the graph the difference between n^T and n^A under a given level of country size, and check how the change in the technology differential will shift the n^T line before examining the related impacts.

3.1 Number of firms and country size under autarky (Line-n^A)

The relationship between the number of firms under autarky, n^A, and country size, γ, is represented by equation (10). For simplicity and without losing generality, we choose the unit such that

$$\frac{(1-\theta)sL}{\alpha} = 1, \tag{19}$$

as done by Kikuchi (2001). Thus, equation (10) can be rewritten as follows:

$$n^A = \gamma, \tag{10$'$}$$

which is represented by Line-n^A as shown in Figure 1. Notably, there is a corresponding line for n^{A*}, which is suppressed due to the symmetry setup. In the figure, the horizontal axis represents the relative country size, γ, and ranges between 0 and 1. Furthermore, the vertical axis represents the number of firms, n, and also ranges between 0 and 1. According to equation (10$'$), Line-n^A is a 45° line. Id addition, corresponding to a given γ, n^A can be straightforwardly identified in the same figure.

Some interesting conclusions can be drawn from Figure 1. For the two countries with identical technology and preferences, the larger the country (a higher γ) the greater the number of firms under autarky. More specifically, for a smaller country, i.e., $\gamma < 1/2$ (the other country's size is then $1-\gamma$, by definition), the number of firms for the country will be

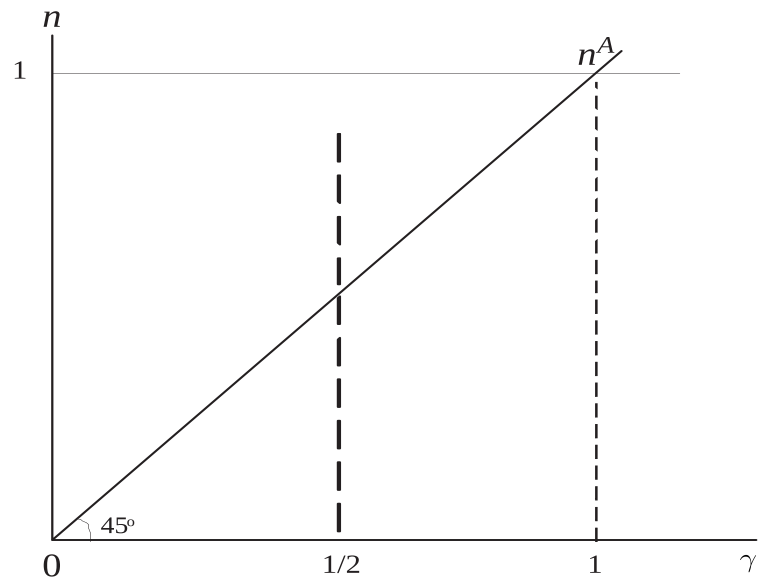

Figure 1: Country size and number of firms under autarky

less than 1/2 (correspondingly, greater than 1/2 for the other large country). For the case where $\gamma = 1/2$, that is, where country sizes are identical, the number of firms should also be equal under autarky, with both shares equal to 1/2.

3.2 Number of firms under free trade (Line-n^T)

Similarly, by making use of equation (19), equation (14) can be simplified as follow:

$$n^T = \frac{\gamma}{(1-\tau\Phi)} - \frac{\tau(1-\gamma)}{\Phi-\tau}. \tag{14'}$$

Obviously, factors affecting the equilibrium number of firms (n^T) under free trade include not only the transport cost τ and relative country size γ, as already addressed in the literature, but also the technology differential Φ between countries. The relationship between the number of firms and relative country size under free trade, represented by equation (14′), can be depicted as Line-n^T in Figure 2.

Before proceeding further, it will be helpful to elaborate on some of the properties of Line-n^T, especially the slope, which as will be shown later is highly affected by the extent

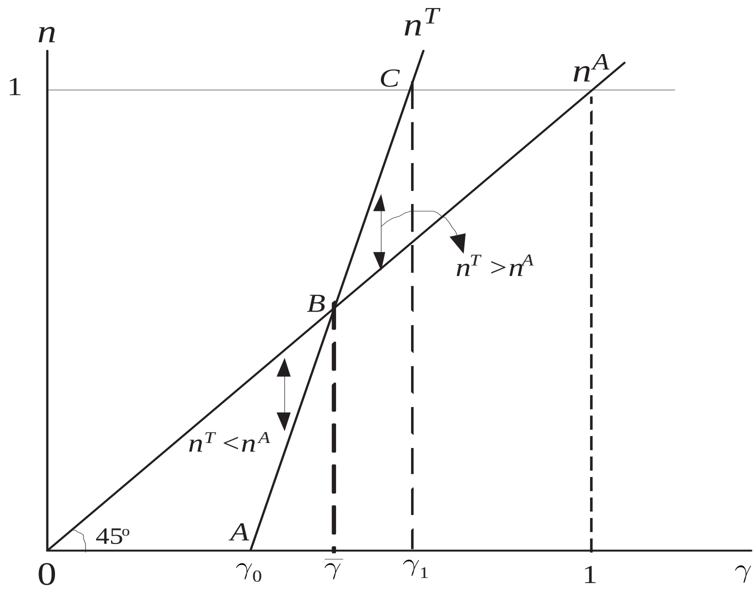

Figure 2: Country size and number of firms under free trade

of the technology difference, and affects the main results of this paper regarding the reversal of the home market effects.

Technology differential and the slope of Line-n^T

From equation (14′), the slope of Line-n^T can be derived as

$$\frac{dn^T}{d\gamma} = \frac{\Phi(1-\tau^2)}{(1-\tau\Phi)(\Phi-\tau)} \; > \; 1, \quad \text{if} \;\; \tau < \Phi < 1/\tau. \tag{14''}$$

In Appendix 2, we prove that if $\tau < \Phi < 1/\tau$, then the slope of Line-n^T will be greater than 1, i.e., steeper than the 45° line (or Line-n^A) as depicted in Figure 2. Moreover, if $\Phi = \tau$, or $\Phi = 1/\tau$, then Line-n^T becomes vertical, i.e., its slope is infinity. It is worth noting here that for the case where $\Phi < \tau$, or $\Phi > 1/\tau$ (that is, the technology differential is big enough), the equilibrium does not exist. This is because, in this case, the slope of Line-n^T becomes negative and its cross point with Line-n^A corresponds to the country size beyond [0,1], which is meaningless by definition.

Since Line-n^T is steeper than Line-n^A, we can see clearly from Figure 2 that there are three cross points: Point A is the cross point of Line-n^T with the horizontal axis, point B that with the n^A line, and point C that with the horizontal line $n = 1$. The relative country sizes corresponding to each of the three points are, respectively, γ_0, $\overline{\gamma}$ and γ_1, and will be expressed mathematically later.

Now we are ready to elaborate on the effect of trade on the number of firms, i.e., the so-called home market effects in the literature. This is done by simply comparing the level of n^T and n^A under a given level of country size γ.

As is clearly seen from Figure 2, for a country with a size γ that is less than $\overline{\gamma}$, trade will result in a decline in its number of firms, i.e., $n^T < n^A$. On the contrary, if the country has a size that is greater than $\overline{\gamma}$, then $n^T > n^A$, implying that trade will increase the country's number of firms. Obviously, this result is consistent with the conventional wisdom regarding home market effects, except that the benchmark country size of $\overline{\gamma}$ may not be equal to 1/2 as in the conventional case. Indeed, as will be shown in the following equation, the extent of the technology advantage will affect the benchmark size of $\overline{\gamma}$.

By using equations (10′) and (14′) and making $n^A = n^T$, the critical country size of $\overline{\gamma}$ based on hte home market effects can be derived as

$$\overline{\gamma} = \frac{(1 - \tau\Phi)}{(1 - \tau\Phi) + \Phi(\Phi - \tau)}. \tag{20}$$

Clearly, there are two factors determining the marginal country size: the technology differential Φ and transport cost τ.

3.3 Revised home market effects

The conventional home market effect indicate that, in a two-country world, a relatively smaller country tends to share a small proportion of the differentiated manufacturing goods. That is, in terms of our model, the benchmark relative country size of $\overline{\gamma}$ is equal to 1/2, should the conventional wisdom regarding the home market effects be correct. From equation (20), however, this is the special case of identical technology between the countries, that is $\Phi = 1$.

The comparative statics yields $\partial\overline{\gamma}/\partial\Phi < 0$, as stated below:

$$\frac{\partial\overline{\gamma}}{\partial\Phi} = \frac{-[(\Phi - \tau) + \Phi(1 - \tau\Phi)]}{[(1 - \tau\Phi) + \Phi(\Phi - \tau)]^2} < 0. \tag{21}$$

Since at $\Phi = 1$, $\overline{\gamma} = 1/2$, equation (21) implies that with $\Phi > 1$ we have $\overline{\gamma} < 1/2$, as shown in Figure 3. An interesting result can be derived from the figure. That is, for a country of a size greater than $\overline{\gamma}$, even if it is smaller than the other country (i.e.,$\overline{\gamma} < \gamma < 1/2$), free trade will enlarge the number of firms in that country's differentiated manufacturing sector.

A symmetric result can be derived immediately in the case where there is a technology disadvantage. More specifically, if $\Phi < 1$, then $\overline{\gamma} > 1/2$, as shown in Figure 4. Clearly, from this figure we can easily find the case where, even for a larger country (i.e., $\gamma > 1/2$), trade may reduce the number of that country's firms, i.e. the home market effects will be reversed, if the country is not big enough ($\gamma < \overline{\gamma}$). The economic intuition behind this result is that the technology disadvantage will to some extent offset the positive home market effects for a large country.

This feature is summarized as Proposition 1:

Proposition 1 (*Home market effects under technology differences*)

A technology advantage can offset the negative home market effects for a small country. Even if that country, it is smaller than the other ($\gamma < 1/2$), *once it has better technology and is not too small* ($\gamma > \overline{\gamma}$), *then free trade can enlarge rather than decrease the number of firms in the differentiated manufacturing sector. On the contrary, a technology disadvantage can offset the positive home market effects for a large country. Even if that country is larger*

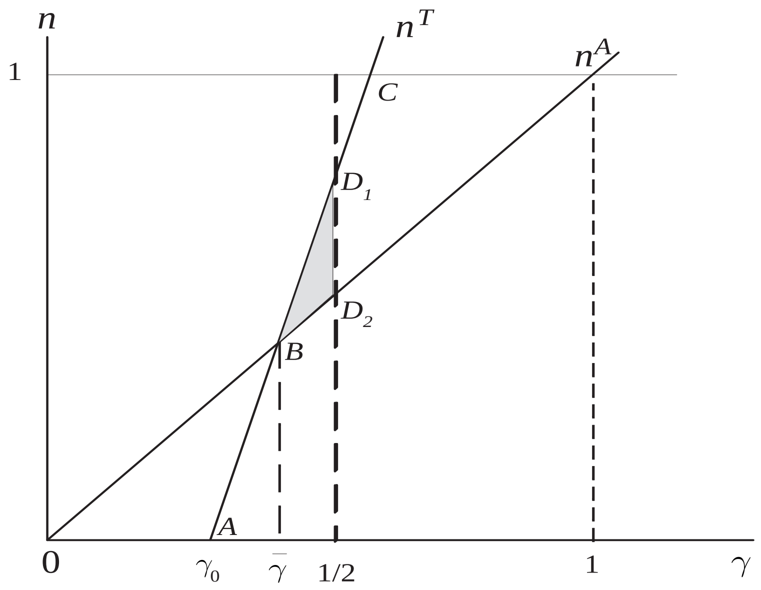

Figure 3: Technology advantage ($\Phi > 1$)

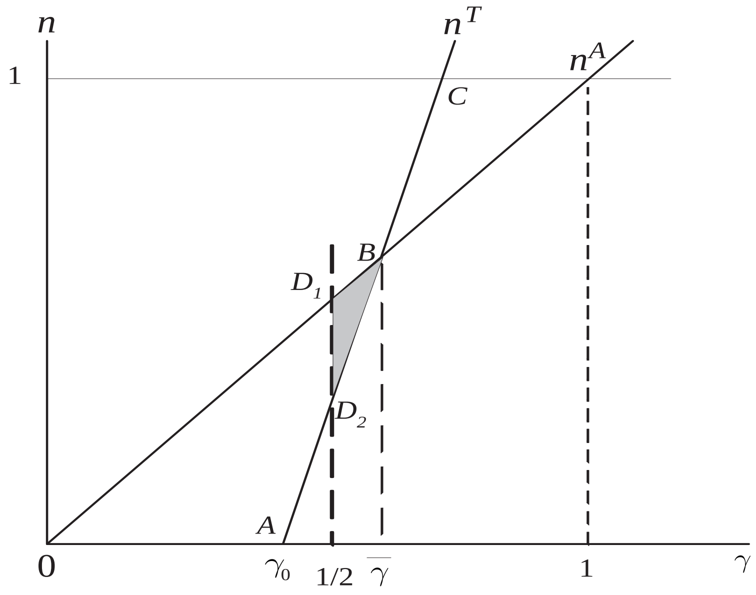

Figure 4: Technology disadvantage ($\Phi < 1$)

than the other ($\gamma > 1/2$)*, once it has poorer technology and is not big enough* ($\gamma < \overline{\gamma}$)*, then free trade can decrease rather than increase the number of that country's firms in the differentiated manufacturing sector.*

In addition, simple algebra will show that $\partial n^T/\partial\Phi > 0$, and that $\partial(dn^T/d\gamma)/\partial\Phi \gtreqless 0$ if $\Phi \gtreqless 1$.[1] That is, in the case where $\Phi > 1$, Line-n^T becomes steeper and moves to the left with a higher Φ, as is shown in Figure 5, in which Line-$n^{T\prime}$ corresponds to a higher Φ.

The counterpart, i.e. the case where there is a technology disadvantage, $\Phi < 1$, can be depicted immediately in Figure 6 in which Line-$n^{T\prime}$ corresponds to a smaller Φ. Since $\partial n^T/\partial\Phi > 0$, and $\partial(dn^T/d\gamma)/\partial\Phi < 0$, if $\Phi < 1$, Line-n^T should move to the right and become steeper as Φ decreases. That is, Line-$n^{T\prime}$ is on the right hand side of and steeper than Line-n^T. The economics meaning of this reault is as follows:

Proposition 2 *The higher the degree of technology advantage for a country, the more likely it is that the country will ease its size disadvantage* ($\overline{\gamma}$ *declines*) *and benefit more from free trade in terms of its the numbers of firms* (n^T *increases more for a given country size* γ)*. On the contrary, the greater the technology disadvantage a country faces, the less likely it is that country will benefit from a trade-induced size advantage* ($\overline{\gamma}$ *increases*) *and will thus suffer more from free trade in terms of a decrease in the number* (n^T *decreases more, or increases less for a at given country size*)*.*

An interesting implication from Proposition 2 can be derived immediately, when the technology advantage is extremely high, i.e., $\Phi \simeq 1/\tau$. In such a case Line-n^T becomes almost vertical, and close to the vertical axis. Furthermore, even a very small country can

[1]See Appendix 2 for the mathematical derivation.

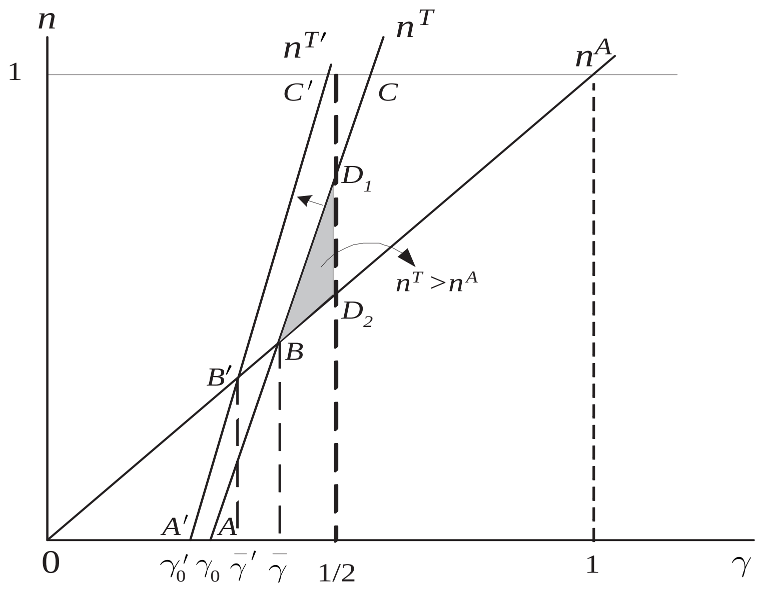

Figure 5: Technology advantage ($\Phi > 1$) effect of an increase in Φ

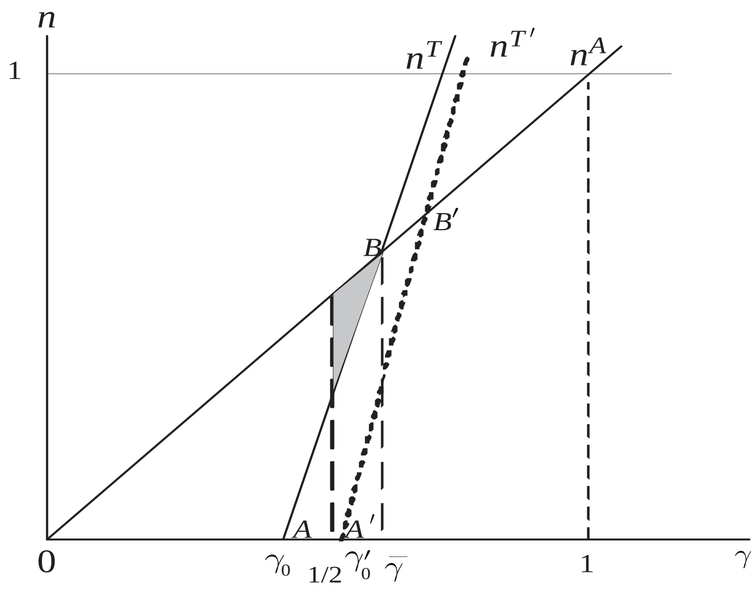

Figure 6: Technology disadvantage ($\Phi < 1$) effect of a decrease in Φ

capture the whole of the world market once it has an extreme technology advantage over its trading partners.

3.4 Core-periphery pattern

Some interesting results regarding the core-periphery pattern arising from free trade can also be derived by examining the figures. Figure 2, firstly, shows that under free trade a country smaller than γ_0 will lead to the extinction of firms in the manufacturing sector, i.e., $n^T = 0$ for $\gamma < \gamma_0$, a case of a complete hollowing out or de-industrialization under free trade. For convenience, we refer to γ_0 as the threshold of peripherization, which can be derived by letting $n^T = 0$ as shown below:

$$\gamma_0 = \frac{(1 - \tau\Phi)\tau}{\Phi - \tau + (1 - \tau\Phi)\tau}. \tag{22}$$

Secondly, we can derive mathematically the effect of Φ on the peripherization threshold, γ_0, as equation (23)

$$\frac{\partial \gamma_0}{\partial \Phi} = \frac{-\tau(1 - \tau^2)}{[\Phi - \tau + (1 - \tau\Phi)\tau]^2} < 0. \tag{23}$$

This equation states that the higher the degree of technology advantage, Φ, the lower the threshold level of the periphery γ_0, i.e., to become a trade-induced periphery in the manufacturing sector, the country size should be even smaller. In other words, the higher the technology advantage, the less likely it is that a country will become a manufacturing periphery under free trade. Proposition 3 summarizes the results:

Proposition 3 (*A technology advantage offsets the likelihood of trade-induced de-industrialization*)

For a country that is small enough, free trade will lead to the extinction of the manufacturing sector that is caracterize by scale economies. However, with a technology advantage, the likelihood of being peripherized a (*complete hollowing out effect or de-industrialization*)

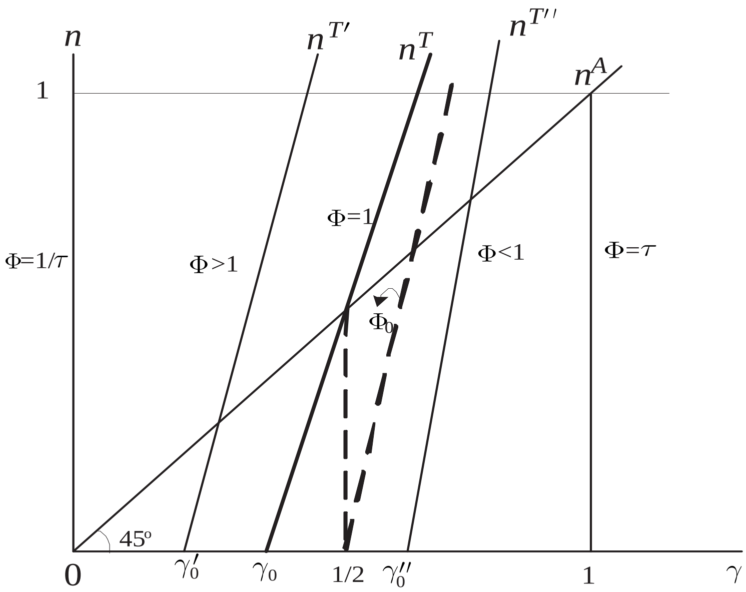

Figure 7: $\tau < \Phi < 1/\tau$

will decrease. The higher the degree of technology advantage, the less likely it is that the country will be peripherized under free trade.

As noted earlier, based on the properties of Line-n^T under the case where there is a technology disadvantage ($\Phi < 1$), a lower Φ moves Line-n^T to the right and makes the line steeper. It follows immediately that there exists a level of Φ, denoted as Φ_0, such that the corresponding threshold of the periphery equals one half, i.e., $\gamma_0 = 1/2$. Mathematically, by using equation (22) and letting $\gamma_0 = 1/2$, one can derive $\Phi_0 = 2\tau/(1+\tau^2)$.[2] Furthermore, by $\partial\gamma_0/\partial\Phi < 0$, we have $\gamma_0 > 1/2$ for all $\Phi < \Phi_0$. Line-$n^{T''}$ in Figure 7 illustrates this case. Accordingly, if the country size is less than γ_0'', even if it is the bigger country (that is, γ is still greater than 1/2), free trade will make the big country become a periphery of the non-manufacturing sector. This implies that a big country may end up completely de-industrialized due to free trade, provided that its technology disadvantage is sufficiently serious.

[2]See Appendix 3 for the mathematical derivation.

In addition, by simple algebra it can be proved that $\partial\Phi_0/\partial\tau > 0$,[3] implying the higher the transport cost (a lower τ) the more severe the technology disadvantage (a lower Φ_0) that is required in order to have the big-country's de-industrialization occur under free trade. In other words, the transport cost plays a positive role in preventing a country with a technology disadvantage from deindustrializing under trade. Thus, we have the following proposition:

Proposition 4 *Free trade can cause a large country to become fully de-industrialized, if its technology disadvantage is severe enough. However, a higher transport cost will decrease the likelihood of full de-industrialization arising from the technology disadvantage.*

3.5 Intra-industry trade and technology differential

An interesting case worth noting is to examine how the difference in technology may affect the likelihood of intra-industry trade (IIT) in the differentiated sector, especially when country sizes are identical across countries, i.e., $\gamma = 1/2$. The conventional IIT pattern is derived on the basis of identical country size and technology. Here, we illustrate from that under identical country size, the IIT will occur only under a given range of technology differential. In Appendix 3 that, under an identical country size, the IIT will occure only under a given range of technology differential. In the appendix we prove that

$$\gamma_0 \left\{ \begin{array}{c} < \\ = \\ > \end{array} \right\} \frac{1}{2}, \quad \text{if} \quad \left\{ \begin{array}{l} \Phi_0 < \Phi < 1 \\ \Phi = \Phi_0 = \frac{2\tau}{1+\tau^2} \\ \tau < \Phi < \Phi_0 \end{array} \right. . \tag{24}$$

Note that, based on the definition of Φ which denotes the technology advantage for the home country, the corresponding index for the foreign country denoted as Φ^* should equal $1/\Phi$. Now, suppose that the home country has better technology, i.e., $\Phi > 1$. As illustrated

[3] $\partial\Phi_0/\partial\tau = 2(1-\tau^2)/[(1+\tau^2)^2] > 0$.

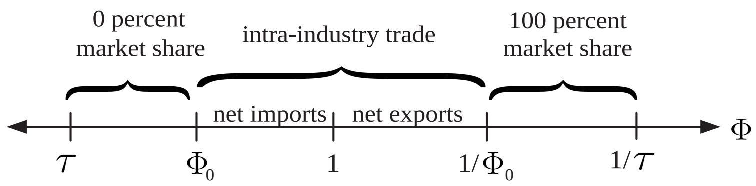

Figure 8: Technology differential and pattern of trade

earlier, the home country will experience an expansion in the differentiated sector after free trade. On the contrary, the foreign country will lose market share by decreasing the number of firms in the industry. In the extreme, if a complete hollowing out occurs in the foreign country, i.e., the case where $\gamma_0^* > 1/2$ for the foreign country, then the trade pattern will be such that IIT will not occur. It follows immediately from equation (24) that, in order to have $\gamma_0^* > 1/2$ so that the foreign country's differentiated industry completely dies out after trade, that country's technology disadvantage should lie within the range $\tau < \Phi^* < \Phi_0$, as shown in Figure 8.

On the other hand, the foreign country can still have its industry surviving although the number of its firms will decrease due to trade, provided that its technology disadvantage is not too severe, i.e., $\Phi_0 < \Phi^* < 1$. By noting that the technology difference index for the foreign country Φ^* is just the inverse of Φ, we can easily identify several patterns of trade under different levels of Φ. In the case of IIT, a country with better technology $(1 < \Phi < 1/\Phi_0)$ will be the net exporter, while the other country (by definition its technology index is $1/\Phi$) will be the net importer. The range of the technology differential $[\Phi_0, 1/\Phi_0]$ as shown in Figure 8 is positively affected by the level of transport cost. That is, the lower the value of τ, the larger the range of $[\Phi_0, 1/\Phi_0]$. Proposition 5 summarizes the results:

Proposition 5 *With identical country size, intra-industry trade occurs if the technology differential* (Φ) *lies within the range* $[\Phi_0, 1/\Phi_0]$ *and* $\Phi_0 = 2\tau/(1+\tau^2)$. *Furthermore, the higher* *the transport cost (lower τ), the larger the range will be; the country with better technology will be the net exporter of the differentiated goods, while the other country wiil be the net importer. The technology differential beyond this range indicates that free trade will lead to a complete hollowing out of the differentiated industry in the case of the technology disadvantaged country, while the technology advantaged country will take up the whole market.*

4 Concluding remarks

The conventional home market effects indicate that a larger country will tend to have a more than proportionate share of differentiated industries, since with increasing returns, transport cost gives an advantage to firms located in larger markets. However, this result is derived under specific assumptions in the Helpman-Krugman model. By departing from the standard Helpman-Krugman modeling assumptions, the home market effects reversal may occur under a different set-up, such as where transport cost is considered in homogeneous goods (Davis 1998), Cournot competition (Head, et al. 2002), the endogenous expenditure share (Yu 2005), and national (rather than firm) product differentiation (Feenstra, et al. 2001, Head and Ries 2001).

However, most of the literature regarding the home market effects still assumes identical technology across countries. Theoretically, differences in technology can play an important role in affecting the trade pattern, as illustrated in the conventional Ricardian model. In the Ricardian world, we can easily find that the better the technology of a country in an industry, the more likely it is that the country will be the major or only producer of the goods, even though the country may be smaller than its trading partner. As a complement, we extend the conventional home market effects model to allow for differences in technology, and illustrate that a technology advantage can offset or even reverse the home market effects.

That is, a small country with sufficiently better technology will result in the enlargement rather than shrinkage of the differentiated industry under free trade.

The major findings of this paper are as follows:

(1) A technology advantage can offset the negative home market effects of a relatively small country and enhance the positive home market effects for a larg country.

(2) The larger the technology advantage of the smaller country, the more likely it is that the home market effect will be offset, and in the extreme, lead to the reversal of the home market effects. That is, trade will induce the expansion of the smaller country in the differentiated sector at the expense of shrinkage in the case of the larger country.

(3) For a country that is small enough, free trade will lead to the extinction of the manufacturing sector characterized by economies of scale , i.e., there will be a complete hollowing out effect or de-industrialization. However, with a technology advantage, the likelihood of being peripherized decreases. The higher the degree of technology advantage, the less likely it is that such a country will be peripherized under free trade.

(4) After considering differences in technology, the conventional wisdom regarding intra-industry trade in the increasing return sector should be revised. We show that, even under identical country size, IIT may not occur if the technology difference is big enough.

Appendix 1 Derivations of the equilibrium number of firms under free trade (n^T and n^{T*})

Instead of solving for n and n^* directly from equations (11) and (13), we adopt the following strategy. In the first step, $1/\phi_1$ and $1/\phi_2$ are regarded as new variables and are solved from equations (11) and (13) to yield $1/\phi_1 = \phi'(\cdot)$ and $1/\phi_2 = \phi'(\cdot)$. Secondly, the results are substituted into equation (12) to solve for n and n^*.

Step 1: Solving for $1/\phi_1 = \phi'(\cdot)$ and $1/\phi_2 = \phi'(\cdot)$

Equations (11) and (13) can be rewritten in matrix form as

$$\begin{bmatrix} w\gamma & \tau w^*(1-\gamma) \\ \tau w\gamma & w^*(1-\gamma) \end{bmatrix} \begin{bmatrix} \frac{1}{\phi_1} \\ \frac{1}{\phi_2} \end{bmatrix} = \begin{bmatrix} \frac{\theta}{(1-\theta)} \frac{\alpha}{\beta} \frac{1}{p^{\frac{1}{\theta-1}} sL} \\ \frac{\theta}{(1-\theta)} \frac{\alpha^*}{\beta^*} \frac{1}{p^{*\frac{1}{\theta-1}} sL} \end{bmatrix}. \tag{A.1}$$

Denoting the determinant of the matrix as $\Delta \equiv ww^*\gamma(1-\gamma)(1-\tau^2)$, and using Cramer's rule we obtain

$$\begin{aligned} \frac{1}{\phi_1} &= \phi_1'(\alpha, \beta, w, \alpha^*, \beta^*, w^*, \tau, \gamma, \theta, s, L) \\ &= \frac{\theta}{(1-\theta)sL} \frac{1}{w\gamma(1-\tau^2)} \left[\frac{\alpha}{\beta} p^{\frac{1}{1-\theta}} - \tau \cdot \frac{\alpha^*}{\beta^*} \cdot p^{*\frac{1}{1-\theta}} \right], \end{aligned} \tag{A.2}$$

$$\begin{aligned} \frac{1}{\phi_2} &= \phi_2'(\alpha, \beta, w, \alpha^*, \beta^*, w^*, \tau, \gamma, \theta, s, L) \\ &= \frac{\theta}{(1-\theta)sL} \frac{1}{w^*(1-\gamma)(1-\tau^2)} \left[\frac{\alpha^*}{\beta^*} p^{*\frac{1}{1-\theta}} - \tau \cdot \frac{\alpha}{\beta} \cdot p^{\frac{1}{1-\theta}} \right]. \end{aligned} \tag{A.3}$$

Step 2: Solving for n and n^*

By substituting (A.2) and (A.3) into equation (12), we get

$$\begin{bmatrix} p^{\frac{\theta}{\theta-1}} & \tau p^{*\frac{\theta}{\theta-1}} \\ \tau p^{\frac{\theta}{\theta-1}} & p^{*\frac{\theta}{\theta-1}} \end{bmatrix} \begin{bmatrix} n \\ n^* \end{bmatrix} = \begin{bmatrix} \frac{1}{\phi_1'} \\ \frac{1}{\phi_2'} \end{bmatrix}. \tag{A.4}$$

By Cramer's rule, n and n^* can be solved as:

$$n = \frac{1}{p^{\frac{\theta}{\theta-1}}(1-\tau^2)} \Psi_1, \tag{A.5}$$

$$n^* = \frac{1}{p^{*\frac{\theta}{\theta-1}}(1-\tau^2)} \Psi_2, \tag{A.6}$$

where

$$\Psi_1 = \frac{(1-\theta)sLw\gamma(1-\tau^2)}{\theta\left(\frac{\alpha}{\beta}\,p^{\frac{1}{1-\theta}} \;-\; \tau\frac{\alpha^*}{\beta^*}\,p^{*\frac{1}{1-\theta}}\right)} \;-\; \frac{(1-\theta)\tau sLw^*(1-\gamma)(1-\tau^2)}{\theta\left(\frac{\alpha^*}{\beta^*}\,p^{*\frac{1}{1-\theta}} \;-\; \tau\frac{\alpha}{\beta}\,p^{\frac{1}{1-\theta}}\right)}, \tag{A.7}$$

$$\Psi_2 = \frac{(1-\theta)sLw^*(1-\gamma)(1-\tau^2)}{\theta\left(\frac{\alpha^*}{\beta^*}\,p^{*\frac{1}{1-\theta}} \;-\; \tau\frac{\alpha}{\beta}\,p^{\frac{1}{1-\theta}}\right)} \;-\; \frac{(1-\theta)\tau sLw\gamma(1-\tau^2)}{\theta\left(\frac{\alpha}{\beta}\,p^{\frac{1}{1-\theta}} \;-\; \tau\frac{\alpha^*}{\beta^*}\,p^{*\frac{1}{1-\theta}}\right)} \quad . \tag{A.8}$$

By using $w^*/w = 1$, the results can be simplified further as shown below: (The superscript T is added to n and n^* to indicate that the variable is at the free trade equilibrium.)

$$n^T = \frac{(1-\theta)sL}{\alpha}\;\left[\frac{\gamma}{1-\tau\Phi} \;-\; \frac{\tau(1-\gamma)}{\Phi-\tau}\right],$$

$$n^{T*} = \frac{(1-\theta)sL}{\alpha^*}\;\Phi\left[\frac{1-\gamma}{\Phi-\tau} \;-\; \frac{\tau\gamma}{1-\tau\Phi}\right],$$

where

$$\Phi \equiv \frac{\alpha^*}{\alpha}\;\left(\frac{\beta^*}{\beta}\right)^{\frac{\theta}{1-\theta}},$$

represents the difference in technology between the countries.

Appendix 2 Derivations of the properties of Line-n^T

1. The slope is greater than one. That is,

$$\frac{dn^T}{d\gamma} = \frac{\Phi(1-\tau^2)}{(1-\tau\Phi)(\Phi-\tau)} \;>\; 1, \quad \text{if} \quad \tau < \Phi < 1/\tau. \tag{14''}$$

Proof:

Let $\tau < \Phi < 1/\tau$. Suppose that

$$\frac{\Phi(1-\tau^2)}{(1-\tau\Phi)(\Phi-\tau)} \leq 1$$

$$\Rightarrow \qquad \Phi - \Phi\tau^2 \leq \Phi - \tau - \tau\Phi^2 + \tau^2\Phi$$

$$\Rightarrow \qquad (1-\tau\Phi) \leq \Phi(\tau - \Phi).$$

Obviously, this is contradictory to the presumption that $\tau < \Phi < 1/\tau$. Q.E.D.

2. The number of firms increases as the technology difference increases. That is

$$\frac{\partial n^T}{\partial \Phi} > 0.$$

By equation (14′), we have

$$\frac{\partial n^T}{\partial \Phi} = \frac{\gamma\tau}{(1-\tau\Phi)^2} + \frac{(1-\gamma)\tau}{(\Phi-\tau)^2} > 0. \tag{A.9}$$

3. The relation between the slope and technology differential is ambiguous.

That is,

$$\frac{\partial(\frac{dn^T}{d\gamma})}{\partial \Phi} \gtreqless 0, \text{ if } \Phi \gtreqless 1.$$

Proof:

By equation (14″), we have

$$\begin{aligned}\frac{\partial\left(\frac{dn^T}{d\gamma}\right)}{\partial \Phi} &= \frac{(1-\tau^2)}{(1-\tau\Phi)(\Phi-\tau)} - \frac{\Phi(1-\tau^2)[(-\tau)(\Phi-\tau)+(1-\tau\Phi)]}{[(1-\tau\Phi)(\Phi-\tau)]^2} \\ &= \frac{\tau(1-\tau^2)(\Phi^2-1)}{[(1-\tau\Phi)(\Phi-\tau)]^2} \gtreqless 0, \text{ if } \Phi \gtreqless 1. \end{aligned}$$

Q.E.D.

section*Appendix 3 Derivations of the properties of the $\overline{\gamma}$ and γ_0

1. The $\overline{\gamma}$ and γ_0 decrease as Φ increases.

Based on equations (21) and (23), we have

$$\frac{\partial \overline{\gamma}}{\partial \Phi} < 0, \quad \frac{\partial \gamma_0}{\partial \Phi} < 0.$$

2. If $\Phi = 1$, then the $\overline{\gamma}$ is equal to 1/2 and the γ_0 is less than 1/2, that is

$$\overline{\gamma} = \frac{1}{2},\ \gamma_0 = \frac{\tau}{1+\tau} < \frac{1}{2}, \quad \text{if } \Phi = 1. \tag{A.10}$$

If $\Phi > 1$, then the $\overline{\gamma}$ and γ_0 is less than 1/2, that is

$$\overline{\gamma} < \frac{1}{2},\ \gamma_0 < \frac{1}{2}, \quad \text{if } \Phi > 1. \tag{A.11}$$

If $\Phi < 1$, then the $\overline{\gamma}$ is greater than 1/2, but γ_0 can be greater or less than or equal to 1/2, that is

$$\overline{\gamma} > \frac{1}{2},\ \gamma_0 \gtreqless \frac{1}{2}, \quad \text{if } \Phi < 1. \tag{A.12}$$

3. Let $\gamma_0 = 1/2$. By using equation (22), we can derive a level of technology differential $\Phi_0 = 2\tau/(1+\tau^2)$, such that

$$\gamma_0 \left\{ \begin{array}{c} < \\ = \\ > \end{array} \right\} \frac{1}{2}, \quad \text{if} \quad \left\{ \begin{array}{l} \Phi_0 < \Phi < 1 \\ \Phi = \Phi_0 = \frac{2\tau}{1+\tau^2} \\ \tau < \Phi < \Phi_0 \end{array} \right. .$$

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