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Pakistan office -2 : Rasul Pur Tarar, 52111, Hafizabad, Pakistan- Tel: +92547555001
Website: www.aessweb.com
E-mail: editor@aessweb.com ; editor.aess@yahoo.com

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Technology Difference and Home Market Effects

Abstract

Departing from the original Helpman-Krugman modeling assumptions, we introduce the different endogenous sunk costs of production to trading partners, and show that the home market effects will be affected by the sunk-costs effect and the country-size effect. The sunk-costs effect will dominate the country-size effect. That is, we obtain the result of the reversal home market effects.

Keywords: technology difference; endogenous sunk costs; home market effects

JEL classification: F12

1. Introduction

The purpose of this paper is to reexamine the home market effects under the endogenous sunk costs. Following the Dixit and Stiglitz's (1977) preferences and 'iceberg' transport costs, in a monopolistic competition framework, Krugman (1979, 1980) and Helpman and Krugman (1985) show the home market effects meaning that a relatively larger country tends to share a large proportion of the differentiated manufacturing goods characterized due to scale economies.

The existing literature on home market effects specifies the linear labor requirements with exogenous fixed labor requirements and constant marginal labor requirements. Ricci (1999), Forslid and Wooton (2003) and Huang *et al*. (2014) explore the role of comparative advantage. Ricci (1999) assumes that the marginal costs of production vary across the monopolistically sectors. Forslid and Wooton (2003) suppose that the fixed costs of production are different across the monopolistically sectors. Ricci (1999) and Forslid and Wooton (2003) confirm the home market effects. Conversely, Huang *et al*. (2014) assume that both the marginal costs and the fixed costs of production are different across the monopolistically sectors and then find that the relative technology difference may lead to a reversal home market effects.

However, it is quite possible that a country's industry faces a higher endogenous sunk cost, for example, IT industry and mobile industry. Hence, in another development in the home market effects literature, Sutton (1991, 1998) and Eckel (2008) address the importance of the labor requirements with endogenous sunk costs on the home market effects. They prove that a relatively smaller country tends to decrease the number of firms in a monopolistic competition sector after free trade.

As a complement to the literature, we will consider the difference in technologies of production between countries containing the different sunk costs. In the popular Helpman-Krugman framework, we prove that there are two effects affecting the home market effects, i.e., the sunk-costs effect and the country-size effect. The sunk-costs effect implies that an increase in the endogenous sunk costs can act as a barrier to entry and then lead to a decrease in the number of firms in a larger market size. Conversely, the country-size effect is the conventional home market effects which increase the number of firms in a larger market size. The sunk-costs effect will dominate the country-size effect. In sum, we find that the home market effects will reverse due to the different sunk costs between countries.

The remainder of this paper is organized as follows. Section 2 constructs the theoretical model. Section 3 solves for the equilibrium under both autarky and free trade. Section 4 concludes the paper.

2. The Model

There are two countries in the world, Home and Foreign denoted by an asterisk (*) and assume that they are similar with regard to consumers' preferences but not necessarily in their sizes and production technologies. Labor is the only factor of production and the relative country size is measured by the labor force. L represents the size of the world's total labor force. γL ($0<\gamma<1$) belongs to the home country and $(1-\gamma)L$ belongs to foreign. Hence, γ represents the relative home country size. Suppose that there are two sectors in each country. A competitive sector produces homogeneous goods (Y), and a monopolistic competition sector produces a large number of varieties of the firm-specific differentiated goods (X). The homogeneous goods are produced with constant returns to scale technology and taken as the *numeraire*.

Suppose that there is a positive transport cost for the differentiated goods under free trade. That is, the international shipment incurs an 'iceberg' transport cost wherein for t ($t>1$) units of the differentiated goods shipped, only one unit arrives. Hence, the home's price of the imported differentiated goods is tp^*, where p^* represents the producer's price for foreign. In addition, assume that the homogeneous goods are costless and each country produces them under free trade. The assumption of identical technology in this sector implies that the wage rates are equal between home country and foreign country after trade.

With the assumption of the same consumers' preferences between home country and foreign country, the utility function can be specified as follows:

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

where C_Y represents the consumption of the homogeneous goods, C_X represents the quantity index of the differentiated goods consumed, and s is the share of spending on the differentiated goods. The well-know form of the quantity index can be shown as follows:

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

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

Solving the consumer's utility maximization problem can obtain Home 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 is the price of Home product i and P is the price index for the differentiated goods. w is the nominal wage and hence $w\gamma L$ is the income of the home country. And then, the demand function for foreign product i on the part of home consumers (c_i') can be derived as follows:

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

Similarly, we can derive the foreign consumers' demand function for the foreign goods (c_i*), and for the imported goods from the home country (c_i'*), as follows:

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

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

The price index for the differentiated goods can be derived as:

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

Assume that one unit output requires one unit labor input in the homogeneous sector. In the monopolistically competitive sector, following Dasgupta and Stiglitz (1980), suppose that the amount of labor required l_i (l_i^*) to produce the quantity x_i (x_i^*) is given by:

$$l_i = \alpha (x_i)^{\frac{1}{\alpha}} - 1, \qquad l_i^* = \alpha^* (x_i^*)^{\frac{1}{\alpha^*}} - 1, \qquad \alpha > 1, \ \alpha^* > 1. \tag{6}$$

The parameter α (α^*) is the technology factor. Apart from the traditional set-up which labor requirements are linear with exogenous fixed labor requirements and constant marginal labor requirements, we allow for labor requirements with endogenous sunk costs.[1] While the elasticity of labor requirements of the traditionally linear labor requirements function is increasing in output (x_i), the elasticity of labor requirements with endogenous sunk costs is decreasing in output. The differences in the characters of the elasticity of labor requirements are importance in our analysis. In addition, an increase in α (α^*) will lead to a rise in sunk costs for Home (Foreign).

[1] For alternative specifications of labor requirements function with endogenous sunk costs, please see Leahyand Neary (1996) and Spence (1984).

3. Equilibrium

First, we will derive the autarky equilibrium in Sections 3.1.

3.1 Autarky equilibrium

Obviously, c_i' =0 represents the home country under a state of autarky. Each monopolistic competition firm will take the exogenous price index *P*. In the monopolistic competition equilibrium, two conditions must hold, i.e., profit maximization and the zero-profit condition. Hence, from the profit maximization condition, we have

$$p_i = \frac{w(x_i)^{\frac{1}{\alpha}-1}}{\theta}, \qquad p_i^* = \frac{w^*(x_i^*)^{\frac{1}{\alpha^*}-1}}{\theta}. \tag{7}$$

The zero-profit condition implies that the unit price of p_i (p_i^*) equals the average cost. By making use of the zero-profit condition and Equation (7), the equilibrium quantity of production for the home (foreign) firm x_i (x_i*) can be derived as follows:

$$x_i = \left(\frac{\theta}{\alpha\theta-1}\right)^{\alpha}, \qquad x_i^* = \left(\frac{\theta}{\alpha^*\theta-1}\right)^{\alpha^*}. \tag{8}$$

Substituting Equation (8) into (7) can obtain the unit prices of Home and Foreign as follows:

$$p_i = \frac{w(\alpha\theta-1)^{\alpha-1}}{\theta^{\alpha}}, \qquad p_i^* = \frac{w^*(\alpha^*\theta-1)^{\alpha^*-1}}{\theta^{\alpha^*}}. \tag{7a}$$

For simplification, we delete subscript *i* in what follows. And then, in the home (foreign) differentiated sector, the full employment condition can be shown as follows:

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

Substituting Equation (8) into (9) can obtain:

$$n^A = s\gamma L(\alpha\theta-1) > 0,\ \text{if}\ \frac{1}{\alpha} < \theta < 1;\ n^{A^*} = s(1-\gamma)L(\alpha^*\theta-1) > 0\ \text{if}\ \frac{1}{\alpha^*} < \theta < 1. \tag{10}$$

The superscript '*A*' denotes 'autarky' in Equation (10). In order to let $n^A > 0$ and $n^{A^*} > 0$ hold, we assume $1/\alpha < \theta < 1$ and $1/\alpha^* < \theta < 1$. Next, we will derive the free trade equilibrium in Section 3.2.

3.2 Free trade equilibrium and home market effects

Under free trade, the world market clearing condition for each of the differentiated goods of the home firms (*x*) should satisfy x=c+c'*. Using Equations (3), (4a), and (8) can obtain the world market clearing condition for each home goods as follows:

$$(\frac{\theta}{\alpha\theta-1})^{\alpha} = p^{\frac{1}{\theta-1}} P^{\frac{\theta}{1-\theta}} sw\gamma L + (tp)^{\frac{1}{\theta-1}} P^{*\frac{\theta}{1-\theta}} tsw^{*}(1-\gamma)L$$

$$= \frac{p^{\frac{1}{\theta-1}} sw\gamma L}{\phi_1} + \frac{\tau p^{\frac{1}{\theta-1}} sw^{*}(1-\gamma)L}{\phi_2}, \qquad (11)$$

where

$$\phi_1 \equiv np^{\frac{\theta}{\theta-1}} + n^{*}\tau p^{*\frac{\theta}{\theta-1}}, \quad \text{and} \quad \phi_2 \equiv n\tau p^{\frac{\theta}{\theta-1}} + n^{*} p^{*\frac{\theta}{\theta-1}}, \qquad (12a)$$

$$\tau \equiv t^{\frac{\theta}{\theta-1}}, \ \ 0 < \tau < 1. \qquad (12b)$$

Similarly, the world market clearing condition for each foreign goods is $x^{*}=c' + c^{*}$. Using Equations (3a), (4), and (8) can obtain the world market clearing condition for each foreign goods as follows:

$$(\frac{\theta}{\alpha^{*}\theta-1})^{\alpha^{*}} = (tp^{*})^{\frac{1}{\theta-1}} P^{\frac{\theta}{1-\theta}} tsw\gamma L + (p^{*})^{\frac{1}{\theta-1}} P^{*\frac{\theta}{1-\theta}} sw^{*}(1-\gamma)L$$

$$= \frac{p^{*\frac{1}{\theta-1}} \tau sw\gamma L}{\phi_1} + \frac{p^{*\frac{1}{\theta-1}} sw^{*}(1-\gamma)L}{\phi_2}. \qquad (13)$$

In order to simplify the model, assume that the homogenous sector remains active in Home and Foreign under free trade, e.g., Feenstra (2003), Davis (1998), Ricci (1999), and Huang *et al*. (2014). The identical technology and costless trade in homogenous goods ensure an identical wage rate between Home and Foreign. That is, the wage rate of Home (w) should be equal to that of Foreign (w^*), i.e., $w=w^*$. Using the relationship of $w=w^*$, Equations (11) and (13) can get:[2]

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

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

Obviously, the superscript 'T' denotes 'free trade'. To analyze the role of technology difference for the home market effects, we have to compare the number of firms both before and after the free trade. From Equations (14) and (10), we get:

[2] Please see Appendix for the mathematical derivation.

$$n^T - n^A = sL\tau(\alpha\theta - 1)\left[\frac{\gamma(\alpha\theta-1)}{(\alpha^*\theta-1)-\tau(\alpha\theta-1)} - \frac{(1-\gamma)(\alpha^*\theta-1)}{(\alpha\theta-1)-\tau(\alpha^*\theta-1)}\right]. \tag{16}$$

For the foreign country, using Equations (15) and (10) has:

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

As in the literature, both transport costs τ and country size γ will affect the home market effects from Equations (16) and (17). In addition to τ and γ, we can observe that the technology factor α (α^*) is also an important factor affecting the home market effects. Because of the symmetry between Home and Foreign, we can only consider the case of Home country. From Equation (16), we can obtain:

$$\lim_{\tau\to 1^-}(n^T - n^A) = sL(\alpha\theta-1)\left[\frac{\gamma(\alpha\theta-1)+(1-\gamma)(\alpha^*\theta-1)}{(\alpha^*-\alpha)\theta}\right] < 0, \quad \text{if} \quad \alpha > \alpha^*. \tag{18}$$

Equation (18) indicates that in the case of the smaller transport cost, if $\alpha > \alpha^*$, then $(n^T - n^A) < 0$ meaning that the home market effects will reverse. The economic intuition can be stated as follows. From Equation (18), we find that there are two effects affecting the home market effects. The first effect named as the sunk-costs effect shows that the larger technology factor (α) represents the higher sunk costs and hence the firms have to accomplish higher mark-ups in order to cover these extra sunk costs.[3] But higher mark-ups are only enforceable when the market is less competitive, so that the number of firms must decrease. Namely, the sunk-costs effect will lead to a decrease in the number of firms. The second effect is the conventional country-size effect. The country-size effect argues that in a two-country world, a relatively larger country tends to share a large proportion of the differentiated manufacturing goods. That is to say, the country-size effect will lead to an increase in the number of firms. More specifically, the sunk-costs effect dominates the country-size effect and hence we conclude that the home market effects will reverse.

This feature is summarized as Proposition 1:

Proposition 1. *In the case of the smaller transport cost, the sunk-costs effect dominates the country-size effect. Therefore, the home market effects will reverse.*

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[3] In the case of Home, by using Equations (8) and (6), the marginal cost (*MC*) can be derived as: $MC = w\theta^{(1-\alpha)}(\alpha\theta-1)^{(\alpha-1)}$. Substituting Equation (8) into (7) can get $p = w\theta^{(-\alpha)}(\alpha\theta-1)^{(\alpha-1)}$. Hence, we obtain $\partial(p-MC)/\partial\alpha = w\theta^{(-\alpha)}(\alpha\theta-1)^{(\alpha-1)}\{[\theta(1-\theta)(\alpha-1)/(\alpha\theta-1)] + \ln[\theta^{(\alpha\theta-1)}(\alpha\theta-1)^{(1-\theta)}]\} > 0$, which implies that an increase in α leads to a rise in mark-ups. The same result can also be obtained in the case of Foreign.

4. Concluding Remarks

Departing from the original Helpman-Krugman modeling assumptions, we introduce the different endogenous sunk costs of production to trading partners, and show that the home market effects will be affected by the sunk-costs effect and the country-size effect. The sunk-costs effect will dominate the country-size effect. That is, we obtain the result of the reversal home market effects.

While Huang *et al*. (2014) adopt the linear labor requirements to show that the relative technology difference may lead to a reversal home market effects, we consider the labor requirements with endogenous sunk costs and prove that the home market effects will reverse.

Appendix Solving for the equilibrium number of firms under free trade

First, from Equations (11) and (13), we have the matrix form as follows:

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

Using Cramer's rule can get:

$$\frac{1}{\phi_1} = \frac{(p^*)^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha\theta-1})^{\alpha} - \tau p^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha^*\theta-1})^{\alpha^*}}{sw\gamma L p^{\frac{1}{\theta-1}} (p^*)^{\frac{1}{\theta-1}} (1-\tau^2)}, \tag{A.2}$$

$$\frac{1}{\phi_2} = \frac{p^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha^*\theta-1})^{\alpha^*} - \tau (p^*)^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha\theta-1})^{\alpha}}{sw^*(1-\gamma) L p^{\frac{1}{\theta-1}} (p^*)^{\frac{1}{\theta-1}} (1-\tau^2)}. \tag{A.3}$$

From Equations (A.2) and (A.3), we find:

$$\phi_1 = \frac{sw\gamma L p^{\frac{1}{\theta-1}} (p^*)^{\frac{1}{\theta-1}} (1-\tau^2)}{(p^*)^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha\theta-1})^{\alpha} - \tau p^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha^*\theta-1})^{\alpha^*}}, \tag{A.2a}$$

$$\phi_2 = \frac{sw^*(1-\gamma) L p^{\frac{1}{\theta-1}} p^{*\frac{1}{\theta-1}} (1-\tau^2)}{p^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha^*\theta-1})^{\alpha^*} - \tau (p^*)^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha\theta-1})^{\alpha}}. \tag{A.3a}$$

Second, substituting Equations (A.2a) and (A.3a) into Equation (12a) can obtain the matrix form as follows:

$$\begin{bmatrix} p^{\frac{\theta}{\theta-1}} & \tau p^{*\frac{\theta}{\theta-1}} \\ \tau p^{\frac{\theta}{\theta-1}} & p^{*\frac{\theta}{\theta-1}} \end{bmatrix} \begin{bmatrix} n \\ n^* \end{bmatrix} = \begin{bmatrix} \dfrac{sw\gamma L p^{\frac{1}{\theta-1}} (p^*)^{\frac{1}{\theta-1}} (1-\tau^2)}{(p^*)^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha\theta-1})^{\alpha} - \tau p^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha^*\theta-1})^{\alpha^*}} \\ \dfrac{sw^*(1-\gamma) L p^{\frac{1}{\theta-1}} p^{*\frac{1}{\theta-1}} (1-\tau^2)}{p^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha^*\theta-1})^{\alpha^*} - \tau (p^*)^{\frac{1}{\theta-1}} (\frac{\theta}{\alpha\theta-1})^{\alpha}} \end{bmatrix}. \qquad \text{(A.4)}$$

By using Cramer's rule, the relationship of w=w*, and Equation (7a), we can derive n^T and n^{T^*} as follows:

$$n^T = sL(\alpha\theta-1)(\alpha^*\theta-1)\left[\frac{\gamma}{(\alpha^*\theta-1)-\tau(\alpha\theta-1)} - \frac{\tau(1-\gamma)}{(\alpha\theta-1)-\tau(\alpha^*\theta-1)}\right], \qquad \text{(A.5)}$$

$$n^{T^*} = sL(\alpha\theta-1)(\alpha^*\theta-1)\left[\frac{(1-\gamma)}{(\alpha\theta-1)-\tau(\alpha^*\theta-1)} - \frac{\tau\gamma}{(\alpha^*\theta-1)-\tau(\alpha\theta-1)}\right]. \qquad \text{(A.6)}$$

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