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“Welfare Enhancing Capital Imports”

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Welfare Enhancing Capital Imports*

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Abstract

This paper provides a model to consider the conditions under which an acceptance of foreign capital is welfare enhancing in a multi-commodity multi-factor framework. Contrary to the pessimistic conventional wisdom of capital imports and welfare, we provide a justification for the acceptance of foreign capital and the diversification of industrial structure in developing countries. A sufficient condition for the acceptance of foreign capital to be welfare enhancing is that all domestic factors move into the new export sector in equal proportion to the endowments of factors.

JEL Classification: F11, F21

Keywords: foreign capital, export sector, tariff revenue, welfare

1. Introduction

As the recent experiences demonstrate, instead of import substitution, many developing countries are trying to diversify the industrial structure and making export-led growth by accepting foreign capital. In order to consider the implications of these policies, it is necessary to provide a model to justify the acceptance of foreign capital.

The analysis of capital imports and welfare was a hot issue in 1970s and 1980s and many seminal papers have been written on this topic. Among them, Bhagwati(1973), Brecher and Diaz Alejandro(1977), Brecher and Choudhri(1982), Brecher and Findlay(1983), Minabe(1974) and Srinivasan (1983) made important contributions to the analyses in this field. Specifically, Brecher and Diaz Alejandro(1977) showed that the capital imports under a tariff is immiserizing. In the influential papers in Japanese, Uzawa(1969) and Hamada (1971) showed that the capital imports under a tariff is always welfare reducing for a small open economy. These papers produced a conventional wisdom: the Uzawa-Hamada-Brecher-Diaz Alejandro proposition. Also the welfare effects of a free trade zone and export processing zone have attracted considerable attentions and papers such as Hamada (1974), Miyagiwa (1986) and Beladi and Marjit(1992) have been written.

However the conventional wisdom is pessimistic and do not explain the reality of many developing countries. Furthermore these previous papers have a limitation in dimensionality. These facts motivated us to examine and extend the analyses of capital imports and welfare in more general frameworks. The purpose of this paper is to provide a model to consider the conditions under which an acceptance of foreign capital is welfare enhancing in a multi-dimensional framework. We will provide a sufficient condition for welfare enhancing capital imports.

This paper is organized as follows. In section 2, we take up the conventional wisdom and consider the reasons why such a pessimistic result comes out. The section 3 sets up the model of this paper. In section 4, we provide a sufficient condition for welfare enhancing capital imports and consider its implications. In section 5, we derive a weaker condition by a three-sector, three-factor model which is not only a special case of our model but also an extension of Beladi-Marjit(1992). The section 6 concludes the paper. In the appendix, we consider why our assumption holds in two cases.

2. The Conventional Wisdom

The conventional wisdom, the Uzawa-Hamada-Brecher-Diaz Alejandro proposition, says that the capital import under a tariff is welfare reducing. In order to justify our analysis, it is necessary to consider the reasons why such a pessimistic result comes out.

The proposition uses the Heckscher-Ohlin model and it assumes a small open economy that imports capital intensive good with a tariff. It also assumes that the foreign capital and domestic capital are identical. Assume two commodities Y_1 and Y_2 that are produced by two factors, capital K and labor L, under the usual neo-classical assumptions. The first good is the exportable and labor intensive and the second good is the importable and capital intensive; $k_2 > k_1$, where $k_j \equiv K_j / L_j$, $j = 1,2$. Let the relative price of the second good in terms of the first be $p\,(\equiv p_2 / p_1)$. The first good is the numeraire. Define the GDP function: $G(p,K,L) \equiv \max\left[Y_1(K_1,L_1) + pY_2(K_2,L_2)\right]$ subject to full employment. $G(\cdot)$ is homogeneous of degree one and convex in prices and concave in factor supply. We obtain $G_p = Y_2, G_{pK} > 0, G_{pp} > 0, G_K = r, G_L = w$, where r is the rental of capital and w the wage rate. Define the expenditure function: $E(p,u) \equiv \min\left[D_1 + pD_2\right]$ subject to

$U(D_1, D_2) = u$, where D_j is the consumption of j th good and u the level of utility. It is assumed that both goods are normal. $E(\cdot)$ is homogeneous of degree one and concave in prices and increasing in utility. We obtain $E_p = D_2$, $E_{pp} < 0$, $E_{pu} > 0$. The quantity of import is: $M_2 = E_p(p,u) - G_p(p,K,L)$. Let the specific tariff on import and the foreign capital be t and K_f respectively. The budget equation is:

$$E(p,u) = G(p,K,L) + tM_2 - G_K(p,K,L)K_f, \tag{1}$$

where tM_2 is the tariff revenue and $G_K(p,K,L)K_f$ the repatriation to foreign capital. From (1), we obtain:

$$\frac{du}{dK_f} = -\frac{tG_{pK} + K_f G_{KK}}{E_u - tE_{pu}}. \tag{2}$$

The first term in the numerator in (2) is the tariff revenue effect and the second term the repatriation effect. Since $E(\cdot)$ is homogenous of degree one in prices, we have $E_u - tE_{pu} > 0$. Thus the signs of (2) depend on G_{pK} and G_{KK}. First, in the Heckscher-Ohlin model under incomplete specialization, any change in factor supply does not affect factor prices. Thus we have $G_{KK} = 0$. Second, since the second sector is capital intensive and the capital supply increases, we have $G_{pK} > 0$. Under these specifications, we obtain $du/dK_f < 0$. This is the conventional wisdom and it says that a capital import under a tariff is welfare reducing.

It is clear that this pessimistic result comes from the models and assumptions. Thus if $G_{KK} < 0$ and $G_{pK} < 0$, an capital import is welfare enhancing. In the seminal paper, Jones (1971) has demonstrated that $G_{KK} < 0$ in the specific factor model. By the use of a specific factor model, Srinivasan (1983) showed that the acceptance of foreign capital could be welfare enhancing. The assumption that foreign capital and domestic capital are the same is also crucial in producing the pessimistic result. If they are the same, an acceptance of foreign capital produces $G_{pK} > 0$, reduces tariff revenue and welfare. In this paper, we provide models where $G_{pK} < 0$ occurs.

In this connection, it is necessary to take up Beladi and Marjit(1992) which also produces a pessimistic result even if two types of capital are assumed. It assumes a three-sector (export processing zone, import sector and traditional export sector) three-factor (two capitals and one labor) model. It assumes that foreign capital is used only in the export processing zone while domestic capital is used in the import and traditional export sector but not in the export processing zone. Using such a model, it shows that if the economy imports capital intensive good under a tariff an increase in foreign capital decreases its welfare. It also shows that an increase in foreign capital increases the output of imports and decreases that of exports, making anti-trade growth.[1]

Thus both Heckscher-Ohlin model and Beladi-Marjit model cannot explain the realities of many developing countries. We need a model that can justify the acceptance of foreign capital. Also we must consider a fact that these countries accept foreign capital in order to diversify their industrial structure and attain the export-led growth.[2] Our models in the following sections could achieve these targets.

3. The Model

This section sets up our model. Suppose a small open developing country that produces n commodities $(j = 1,...,n)$ by the use of m factors $(i = 1,...,m)$ before the acceptance of foreign capital. The multi-dimensionality is a first feature of our model.

The production function of each commodity is assumed to be twice-continuously differentiable, increasing, linearly homogeneous and strictly-quasi-concave in all factors of production:

$$y_j = f^j(x_{1j}, x_{2j}, \ldots, x_{mj}), \quad j = 1, \ldots, n. \tag{3}$$

It is assumed that the m factors are inelastically supplied and the full employment condition holds for each of them:

$$\bar{x}_i = \sum_{j=1}^{n} x_{ij}, \quad i = 1, \ldots, m, \tag{4}$$

where $\bar{x}_i$ is the domestic supply of i th factor. All commodity and factor markets are competitive.

Let $p^T \equiv (p_1, p_2, \ldots, p_n)$ be the commodity price vector.[3] The GDP function is defined:

$$F(p, \bar{x}) \equiv \max \sum_{j=1}^{n} p_j f^j(x_{1j}, \ldots, x_{mj}), \tag{5}$$

with respect to x_{ij} $(i = 1, \ldots, m, j = 1, \ldots, n)$ subject to (4), where $\bar{x}^T \equiv (\bar{x}_1, \ldots, \bar{x}_m)$ is the factor-endowment vector of the economy.

Let the new export sector be 0 th sector and suppose that the foreign capital, x_{00} specific to the new export sector, comes into this country and that the new export sector starts by accepting this foreign capital and using all existing domestic factors. We assume that not only foreign capital but also existing domestic factors are used in the new export sector. The assumption that the all existing domestic factors are used in the new export sector is the another feature of our model. This could be justified by the following reasons. First, if all domestic factors are mobile among sectors of the economy, it is natural that they are used in the new export sector. Second, the new export sector cannot be established without the supports of all previous sectors and all previous sectors will support the establishment of new export sector. The assumptions that x_{00} is specific to the new export sector and all existing domestic factors are used in the new export sector are the differences between our model and the Heckscher-Ohlin and Beladi-Marjit(1992) model.[4]

The production function of the new export sector is:

$$y_0 = f^0(x_{00}, x_0), \tag{6}$$

where $x_0^T \equiv (x_{10}, \ldots, x_{m0})$ is the domestic factors used in the new export sector and it has m dimension. We assume that this function also satisfies all the standard properties as a neo-classical production function. We also assume that the new export good is exported at the fixed world price.

Integrating the pre-capital acceptance GDP function with the production function of the 0 th sector, we obtain the post-capital acceptance GDP function:

$$G(p_0, p, \bar{x}, x_{00}) \equiv \max\left[p_0 f^0(x_{00}, x_0) + F(p, \bar{x} - x_0)\right] \tag{7}$$

with respect to x_0. It is assumed that $G(\cdot)$ is differentiable and concave with respect to $\bar{x}$ and x_{00}. Assuming the existence of the interior solution to this maximization problem, we can write the first order condition:

$$p_0 f^0_{x_0}(x_{00}, x_0) = F_x(p, \bar{x} - x_0), \tag{8}$$

where $f^0_{x_0}(x_{00}, x_0)^T \equiv (\dfrac{\partial f^0(x_{00}, x_0)}{\partial x_{10}}, \ldots, \dfrac{\partial f^0(x_{00}, x_0)}{\partial x_{m0}})$,

$$F_x(p, \bar{x} - x_0)^T \equiv (\frac{\partial F(p, \bar{x} - x_0)}{\partial(\bar{x}_1 - x_{10})}, \ldots, \frac{\partial F(p, \bar{x} - x_0)}{\partial(\bar{x}_m - x_{m0})}).$$

(8) shows that the value of marginal product of each existing factor of production is equal between the 0 th sector and previous sectors. Therefore, m equations in (8) are the

profit maximization conditions. Assume that there exists a unique x_0 that satisfies (8).

Now, let us turn to the demand side. Denoting the expenditure function of the whole residents of the country by $E(p_0, p, u)$ and assuming that the government of this country imposes import tariffs and transfers the whole tariff revenue to the residents in a lump-sum manner, we can write the budget constraint:

$$E(p_0, p, u) = G(p_0, p, \bar{x}, x_{00}) + \Gamma^T \left[E_p(p_0, p, u) - G_p(p_0, p, \bar{x}, x_{00})\right]$$
$$- G_{x_{00}}(p_0, p, \bar{x}, x_{00})x_{00}, \qquad (9)$$

where $\Gamma^T \equiv (0,...,0, t_{h+1}, t_{h+2},..., t_n)$ is the import tariff vector. We assume that the first h sectors including the 0 th sector are the export sectors and from $h+1$ to n sector the import sectors. It is assumed that there exits no non-traded goods and all goods are normal. The second term of the right hand side of (9) is the tariff revenue and the third term the repatriation to foreign capital. Since p_0 and p are the domestic prices, by denoting the foreign prices by p_0^* and p^*, we have following relationships:

$$p_0 = p_0^*,$$
$$p = \Gamma + p^*.$$

We assume that (9) determines the welfare level u uniquely and it is denoted by u^e.

4. The Analyses

Now, we derive our main result. The total differentiation of (9) with respect to u^e and x_{00} yields:

$$\left[E_u(p_0, p, u^e) - \Gamma^T E_{pu}(p_0, p, u^e)\right]du^e$$
$$= G_{x_{00}}(p_0, p, \bar{x}, x_{00})dx_{00} - \Gamma^T G_{px_{00}}(p_0, p, \bar{x}, x_{00})dx_{00}$$
$$- G_{x_{00}}(p_0, p, \bar{x}, x_{00})dx_{00} - G_{x_{00}x_{00}}(p_0, p, \bar{x}, x_{00})x_{00}dx_{00}$$

$$= -\left[\Gamma^T G_{px_{00}}(p_0, p, \bar{x}, x_{00}) + G_{x_{00}x_{00}}(p_0, p, \bar{x}, x_{00}) x_{00}\right] dx_{00}.$$

This produces:

$$\frac{du^e}{dx_{00}} = -\frac{\left[\Gamma^T G_{px_{00}}(p_0, p, \bar{x}, x_{00}) + G_{x_{00}x_{00}}(p_0, p, \bar{x}, x_{00}) x_{00}\right]}{E_u(p_0, p, u^e) - \Gamma^T E_{pu}(p_0, p, u^e)}. \tag{10}$$

The first term in the numerator in (10) is the tariff revenue effect and the second term the repatriation effect. We see that they correspond to that in (2). Consider the signs of each term. The denominator of (10) is positive. Since the partial derivative of the expenditure function with respect to u is linearly homogeneous in p_0 and p, we have the Euler condition $E_u = p_0 E_{up_0} + p^T E_{up}$, so that $E_u = p_0 E_{up_0} + (p^* + \Gamma)^T E_{up} > \Gamma^T E_{up}$. Thus the signs of (10) depend on the numerator. Due to the concavity of the GDP function with respect to $\bar{x}$ and x_{00}, $G_{x_{00}x_{00}}(p_0, p, \bar{x}, x_{00}) \leq 0$. It is clear that $G_{x_{00}}$ is the rental rate of foreign capital. As the supply of x_{00} increases the rental rate declines. This is the economic reason why $G_{x_{00}x_{00}}(p_0, p, \bar{x}, x_{00}) \leq 0$. Thus what remains to analyze in the numerator is the term $\Gamma^T G_{px_{00}}(p_0, p, \bar{x}, x_{00})$.[5]

Recalling the definition of the GDP function (7), we see:

$$G_p(p_0, p, \bar{x}, x_{00}) = F_p(p, \bar{x} - x_0). \tag{11}$$

Therefore, we have:

$$G_{px_{00}}(p_0, p, \bar{x}, x_{00}) = -F_{px}(p, \bar{x} - x_0)\frac{dx_0}{dx_{00}}. \tag{12}$$

Thus the sign of $G_{px_{00}}(p_0, p, \bar{x}, x_{00})$ depends on two terms, $F_{px}(p, \bar{x} - x_0)$ and $\dfrac{dx_0}{dx_{00}}$.

As $F_{px}(p, \bar{x} - x_0)$ is the change in the output vector of domestic sectors as the result of an increase in domestic factor supply, it is positive. Thus if the vector $\frac{dx_0}{dx_{00}}$ is positive, an inflow of foreign capital is welfare enhancing. For this purpose, we introduce a following assumption:

Assumption 1. There exists a positive small value α , such that $\frac{dx_0}{dx_{00}} \approx \alpha\bar{x}$.

This assumption implies that all domestic factors move into the new export sector in equal proportion to the endowments of factors. When an inflow of foreign capital takes place, it attracts the existing factors to the new export sector until the rewards to the existing domestic factors is equal between the new export sector and the previous sectors. The assumption 1 says that all domestic factors move into the new export sector in equal proportion to the endowments of factors.

Under this assumption, we see from (12) that $G_{px_{00}}(p_0, p, \bar{x}, x_{00})$ is a negative vector, which implies that $\Gamma^T G_{px_{00}}(p_0, p, \bar{x}, x_{00}) < 0$. From (10), we obtain a following result:

Result 1. An inflow of foreign capital is welfare enhancing under the assumption 1.

The assumption 1 is a sufficient condition for welfare enhancing capital inflow. The intuition is as follows. The movement of all domestic factors into the new export sector reduces the outputs of all previous sectors including the import sectors. Let the output vector of previous sectors be $y^T \equiv (y_1, y_2, ..., y_n)$. Under the assumption 1, we have $dy^T / dx_{00} < 0$, i.e., $dx_0 / dx_{00} > 0$ implies $dy^T / dx_{00} < 0$. This increases the quantity of imports, tariff revenue and welfare.

Let w_0 be the rental rate of foreign capital. Then we obtain:

Remark 1. By the assumption of differentiability of $G(\cdot)$, there exists a reciprocity relation between quantities and prices, i.e., $dy^T / dx_{00} < 0$ implies $dw_0 / dp^T < 0$.[6]

The implications of the remark 1 are as follows. At given foreign capital, suppose that the prices of domestic products increase by an increase in tariffs on imports. An increase in the prices of domestic products increases the prices of domestic factors, which in turn, at given p_0, reduces the rental rate of foreign capital. The reduction of the rental rate of foreign capital reduces the repatriations to foreign country and increases the welfare of this country.

Let us confirm the differences between the conventional wisdom and our results. In the former, it is a two-sector two-factor model, the importable good is capital intensive and foreign capital and domestic capital are identical. In such a case, an increase in foreign capital increases the output of import and reduces the quantity of import, tariff revenue and welfare. In contrast, we assume multi-sectors multi-factors, foreign capital is different from domestic one and specific to the new export sector. As the result of the acceptance of foreign capital, if all domestic factors move into the new export sector in equal proportion, it reduces the outputs of all previous sectors including the import sectors. This increases tariff revenue and welfare. In addition, a new export sector is established.

What remains to consider is the economic justification for the assumption 1. Following justifications could be provided. First, the new export sector is a small size of the economy or a linear contraction of the economy. Second, if all domestic factors are mobile among sectors of the economy, it is natural that all of them are used in the new export sector. Third, except that a new export sector has been added, this type of factor movement leaves the industrial structure unchanged.

5. Three Sectors Three Factors Model

In this section, we derive a weaker condition by a three-sector, three-factor model which is not only a special case of our model but also an extension of Beladi-Marjit(1992).

Assume three sectors: sector 0 is the new export sector, sector 1 the traditional export sector and sector 2 the import sector. The new export good is exported at the fixed world price and the second good is imported with a tariff. Assume three factors: factor x_0 is the foreign capital specific to 0 sector while factors x_1 and x_2 are the domestic factors used in all three sectors. Letting the factor returns to three factors be w_0, w_1, w_2 respectively, the zero profit condition is:

$$p_0 = c^0(w_0, w_1, w_2), \tag{13}$$

$$p_1 = c^1(w_1, w_2), \tag{14}$$

$$p_2 = c^2(w_1, w_2). \tag{15}$$

Differentiating these three equations totally assuming p_0 fixed, we obtain:

$$dw_0 = -\frac{1}{c_0^0}\left[c_1^0 dw_1 + c_2^0 dw_2\right],\ dw_1 = \frac{c_2^2}{\Delta}dp_1 - \frac{c_2^1}{\Delta}dp_2,\ dw_2 = -\frac{c_1^2}{\Delta}dp_1 + \frac{c_1^1}{\Delta}dp_2, \tag{16}$$

where $c_0^0 \equiv \partial c^0 / \partial w_0$, $c_1^0 \equiv \partial c^0 / \partial w_1$, etc., and $\Delta \equiv c_1^1 c_2^2 - c_1^2 c_2^1 = c_1^1 c_1^2 \left[\frac{c_2^2}{c_1^2} - \frac{c_2^1}{c_1^1}\right]$.

From (16), we obtain:

$$\frac{dw_0}{dp_1} = \frac{c_1^0 \left[\frac{c_2^0}{c_1^0} - \frac{c_2^2}{c_1^2} \right]}{c_0^0 c_1^1 \left[\frac{c_2^2}{c_1^2} - \frac{c_2^1}{c_1^1} \right]}, \quad \frac{dw_0}{dp_2} = \frac{c_1^0 \left[\frac{c_2^1}{c_1^1} - \frac{c_2^0}{c_1^0} \right]}{c_0^0 c_1^2 \left[\frac{c_2^2}{c_1^2} - \frac{c_2^1}{c_1^1} \right]}. \tag{17}$$

In (17), $\frac{c_2^0}{c_1^0}, \frac{c_2^1}{c_1^1}$ and $\frac{c_2^2}{c_1^2}$ are the factor intensity of the second factor relative to the first factor in the new export sector, traditional export sector and import sector respectively. The parenthesis in the denominator of (17) is the difference in the factor intensity between the import sector and the traditional export sector. If the import sector is intensive in the second factor relative to the traditional export sector, it is positive. On the other hand, the parenthesis in numerator of (17) is the differences in the factor intensity between the new export sector and the import sector or traditional export sector. We introduce a following assumption:

Assumption 2. $\min\left[\frac{c_2^1}{c_1^1}, \frac{c_2^2}{c_1^2} \right] < \frac{c_2^0}{c_1^0} < \max\left[\frac{c_2^1}{c_1^1}, \frac{c_2^2}{c_1^2} \right]$.

Under the assumption 2 with the reciprocity relation, we obtain:

Result 2. $\frac{dw_0}{dp_1} = \frac{dy_1}{dx_0} < 0$ and $\frac{dw_0}{dp_2} = \frac{dy_2}{dx_0} < 0$.

The result 2 shows that if the factor intensity in the new export sector lies between the two previous sectors an acceptance of foreign capital reduces the outputs of two previous sectors, increasing imports, tariff revenue and welfare. The assumption 2 is weaker than the assumption 1 because we just require that the factor intensity of the second factor relative to the first factor in the new export sector lies between that of other two sectors. We do not require that all domestic factors move into the new export sector in equal proportion to the endowment of factors. If this assumption is satisfied, an acceptance of foreign capital reduces the outputs of two previous sectors, increasing tariff revenue and welfare. It should be noted that this three-sector three factor model is not only a special case of our model but also an extension of Beladi and Marjit (1992).[7]

6. Conclusions

This paper provided a model to consider the welfare effects of capital imports in a multi-dimensional framework and derived a sufficient condition for welfare enhancing capital imports. Our result is optimistic and derived under a multi-dimensional framework. Our model is based on the assumptions that the foreign capital is different from the domestic capital and all domestic factors are used in the new export sector. Under these assumptions, we showed that an acceptance of foreign capital not only increases welfare but also establishes a new export sector in developing countries. This paper also provided a three-sector, three-factor model and derived a weaker condition for welfare enhancing capital imports.

A number of topics suggest themselves for the further researches. First, the assumption 1 may be too strong. We provided three economic justifications. A weaker assumption that reduces only the outputs of import sectors may be desirable. Also the assumption 1 should be examined empirically. Second, the level of technology in the previous sectors may change as the result of capital imports and the full repatriation may not be the case. Third, the assumptions such as perfect competition, perfect factor mobility and full employment may not be suitable for the developing countries. Fourth, the new export good may be consumed domestically. If this is the case, an increase in the variety of consumption may increase its welfare. The generalizations to these aspects are left for the further researches. In spite of these facts, contrary to the conventional wisdom, this paper provided a sufficient condition to justify the acceptance of foreign capital in a multi-dimensional framework.

Appendix

In this appendix, we consider why the assumption 1

$$\frac{dx_0}{dx_{00}} \approx \alpha\bar{x} \tag{a0}$$

holds in two cases: one is when the number of existing commodity n is equal to that of factor m and the other is when they are different.

Case 1. $n = m$

Denote the cost function of the new export sector by $c^0(w_0, w)y_0$, where y_0 is the output of that sector and w is the m dimensional vector of factor prices which is determined by

$$p_i = c^i(w_1,\dots,w_m)\,,\qquad i = 1,\dots,n\,.$$

Let $w(p)$ be the solution vector to this system of equations. Using this solution vector, we can write

$$p_0 = c^0(w_0, w(p))\,, \tag{a1}$$

$$x_{00} = c_0^0(w_0, w(p))y_0\,, \tag{a2}$$

$$x_0 = (c_1^0(w_0, w(p))y_0,\dots,c_m^0(w_0, w(p))y_0)^T\,. \tag{a3}$$

The first equation determines w_0 as $w_0(p_0, p)$ and the rest of equations determine y_0 and x_0. Thus we have:

$$x_0 = \frac{x_{00}}{c_0^0(w_0(p_0, p), w(p))}(c_1^0(w_0(p_0, p), w(p)),\dots,c_m^0(w_0(p_0, p), w(p)))^T\,.$$

Therefore, if the m-dimensional vector

$$(c_1^0(w_0(p_0,p),w(p)),\ldots,c_m^0(w_0(p_0,p),w(p)))^T$$

is proportional to $\bar{x}$, so is x_0, i.e., $x_0 \approx \alpha\bar{x}x_{00}$. In this case we have:

$$\frac{dx_0}{dx_{00}} \approx \alpha\bar{x}.$$

Case 2. $n \neq m$

In this case, $w(=F_x)$ generally depends not only on p but also on $\bar{x}-x_0$. Thus (a1) - (a3) can be rewritten as:

$$p_0 = c^0(w_0, w(p,\bar{x}-x_0)), \tag{a4}$$

$$x_{00} = c_0^0(w_0, w(p,\bar{x}-x_0))y_0, \tag{a5}$$

$$x_0 = (c_1^0(w_0, w(p,\bar{x}-x_0))y_0,\ldots,c_m^0(w_0, w(p,\bar{x}-x_0))y_0)^T. \tag{a6}$$

(a4) determines w_0 as $w_0(p_0,p,\bar{x}-x_0)$ for given p_0, p and $\bar{x}-x_0$.Then from (a5), we can determine y_0. By the use of these, (a6) is written as:

$$x_0 = x_{00}H(p_0,p,\bar{x}-x_0), \tag{a7}$$

where $H(p_0,p,\bar{x}-x_0) \equiv (H_1(p_0,p,\bar{x}-x_0),\ldots,H_m(p_0,p,\bar{x}-x_0))^T$

$$\equiv \left(\frac{c_1^0(w_0(p_0,p,\bar{x}-x_0),w(p,\bar{x}-x_0))}{c_0^0(w_0(p_0,p,\bar{x}-x_0),w(p,\bar{x}-x_0))},\ldots,\frac{c_m^0(w_0(p_0,p,\bar{x}-x_0),w(p,\bar{x}-x_0))}{c_0^0(w_0(p_0,p,\bar{x}-x_0),w(p,\bar{x}-x_0))}\right)^T.$$

Totally differentiating (a7) with respect to x_0 and x_{00}, we obtain:

$$dx_0 = H(p_0,p,\bar{x}-x_0)dx_{00} + x_{00}\nabla[H(p_0,p,\bar{x}-x_0)]dx_0,$$

or

$$\frac{dx_0}{dx_{00}} = H(p_0,p,X) - x_{00}\nabla[H(p_0,p,X)]\frac{dx_0}{dx_{00}}, \tag{a8}$$

where $X \equiv (X_1,\ldots,X_m)^T = (\bar{x}_1 - x_{10},\ldots,\bar{x}_m - x_{m0})^T$ and

$$\nabla[H(p_0, p, X] \equiv \begin{bmatrix} \frac{\partial H_1(p_0, p, X)}{\partial X_1} & \cdot\ \cdot\ \cdot & \frac{\partial H_1(p_0, p, X)}{\partial X_m} \\ \cdot & \cdot\ \cdot\ \cdot & \cdot \\ \cdot & \cdot\ \cdot\ \cdot & \cdot \\ \cdot & \cdot\ \cdot\ \cdot & \cdot \\ \frac{\partial H_m(p_0, p, X)}{\partial X_1} & \cdot\ \cdot\ \cdot & \frac{\partial H_m(p_0, p, X)}{\partial X_m} \end{bmatrix}.$$

From (a8), considering the definition of $H(\cdot)$, we have:

$$\frac{dx_0}{dx_{00}}\Big|_{x_{00}=0} = H(p_0, p, \bar{x} - x_0) =$$

$$\left(\frac{c_1^0(w_0(p_0, p, \bar{x} - x_0), w(p, \bar{x} - x_0))}{c_0^0(w_0(p_0, p, \bar{x} - x_0), w(p, \bar{x} - x_0))}, \ldots, \frac{c_m^0(w_0(p_0, p, \bar{x} - x_0), w(p, \bar{x} - x_0))}{c_0^0(w_0(p_0, p, \bar{x} - x_0), w(p, \bar{x} - x_0))}\right)^T . \quad \text{(a9)}$$

Since our basic assumption is that the coefficient vector of the new export sector is approximately proportional to the endowment vector of the existing factors, i.e., since we assume:

$$\left(\frac{c_1^0(w_0(p_0, p, \bar{x}), w(p, \bar{x}))}{c_0^0(w_0(p_0, p, \bar{x}), w(p, \bar{x}))}, \ldots, \frac{c_m^0(w_0(p_0, p, \bar{x}), w(p, \bar{x}))}{c_0^0(w_0(p_0, p, \bar{x}), w(p, \bar{x}))}\right)^T \approx \alpha\bar{x} .$$

we obtain (a0) as:

$$\frac{dx_0}{dx_{00}}\Big|_{x_{00}=0} \approx \alpha\bar{x} .$$

Footnotes

1. The intuitions are as follows. Suppose that the import sector is capital intensive and traditional export sector labor intensive. An acceptance of foreign capital attracts labor to the export processing zone. This produces a situation where domestic supply of capital has increased. By invoking the Rybczynski theorem, we see that the output of import sector increases and that of traditional export sector declines. This reduces the quantity of import, tariff revenue and welfare.
2. On the analysis of industrialization by the acceptance of foreign technology, see Chen and Shimomura(1998).
3. In what follows, each vector is a column vector. The superscript T implies the transpose of the vector.
4. Our models and assumptions originate from the reflections of the analyses of foreign direct investment as well as the conventional wisdom.
5. $G_{px_{00}}(p_0, p, \bar{x}, x_{00})^T = (\frac{dy_1}{dx_{00}}, \frac{dy_2}{dx_{00}}, ..., \frac{dy_n}{dx_{00}})^T$ is considered as a Rybczynski effect.
6. See, for example, Chang(1979), p - 712.
7. In their model, if the first factor is domestic capital, (13) could be written as $p_0 = c^0(w_0, w_2)$.

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