

**The Effects of Tariff Discrimination on Industrial  
Location and Welfare: Preferential Trading  
Arrangements and Rules of Origin**

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# **The Effects of Tariff Discrimination on Industrial Location and Welfare: Preferential Trading Arrangements and Rules of Origin**

Masaru Umemoto

## **Abstract:**

Rules of origin and their discriminating treatments are likely to become increasingly important issues with the proliferation of preferential trading arrangements (PTAs) in recent years. This paper investigates the effects of PTAs with rules of origin on industrial location and welfare of member and non-member countries. First, a static general equilibrium model based on economic geography is developed to explore possible outcomes. The role of tariff preferences and rules of origin governing the eligibility of producers to enjoy the preferences play an important role on producers' location decisions in this model. This paper shows that the restrictive rules of origin produce the distortion cost to the manufactured good producers and always reduce economic welfare. Therefore, the rules are necessary but they must be achievable to the manufactured good producers.

*Key Words:* rules of origin, preferential trading arrangements, industrial location

*JEL classification:* F12, F15, R12

## 1. INTRODUCTION

This paper investigates the effects of discriminated treatments for manufactured products within a preferential trading area (PTA) on firm location and national welfare. Discriminated treatments are given by rules of origin, which must be met to qualify for preferential passage of products between members of the PTA. The WTO allows the rules of origin if they maintain the neutral position toward trade with countries outside the PTA. However, rules of origin could act as a hidden protection to discriminate the firms owned by non-member countries. Because there is no internationally harmonized consensus for rules of origin, a study on the effects of rules of origin is important.

Some studies have pointed out the discriminating effects of rules of origin (e.g., Krishna and Krueger, 1995; Krueger, 1993). There are also some studies that analyze influence of rules of origin on trade and the market access (e.g., Ju and Krishna, 1998; James and Umemoto, 2000). However, so far as rules of origin could be discriminating measures, not only their influence on trade but that on investment and the enterprise location cannot be ignored. The analysis of the effect of regional integration on investments or industrial location becomes conspicuous recently (Olofsdotter and Torstensson, 1998; Puga and Venables, 1997; Venables, 1995). None of the previous studies, however, analyzes the effects of rules of origin on these variables. It is the purpose of this paper to analyze the influence of rules of origin on the industry location and welfare, which is an extremely important economic issue.

To discuss rules of origin, intermediate good sectors linked with the final good sector that the rules of origin are placed in effect should be considered. Fujita, Krugman

and Venables (1999) basically assume that a manufactured final product uses itself as an input under Dixit-Stiglitz (1977) model. However, this assumption produces the complication in the analysis of the rules of origin. This paper employs the “multistage production model” which has been introduced by Dixit and Grossman (1982) and developed by James and Umemoto (2000). In this model, production is viewed as a sequence of transformations in which components or intermediate inputs are combined until a final good is produced. This model makes the general equilibrium analysis simple and manageable.

The theory of the industry location has recently been developed from the fusion of the economic geography and the trade theory. The monopolistic competition and the economies of scale play important roles in this theory. Although the rules of origin are always related to the regional integration, the economies of scale have not been incorporated into the analysis of the rules of origin yet. Hence, this paper analyzes the effect of rules of origin under the assumption that the final good is a differential product and its market is monopolistically competitive.

This paper is developed as follows. The model used in the analysis is constructed in section 2. Some important assumptions are also explained. Equilibrium conditions in each market are explained in section 3. Section 4 explains the role of the rules of origin in the PTA and provides analysis of the effects of the rules of origin under both the case of following and not following the rules. In section 5, the effects of the rules of origin on the price level and welfare are analyzed. The final section summarizes the findings.

## 2. THE MODEL

The model in this paper is based on the monopolistic competition model, which is introduced by Dixit and Stiglitz (1977) and further developed by Martin and Rogers (1995) and Fujita, Krugman and Venables (1999). The world is assumed to consist of three countries: country 1, country 2 and country 3. Country 1 and country 2 form a PTA such as a free trade area or a custom union, whereas country 3 does not belong to any PTA. Tariff and non-tariff barriers are eliminated for trade between country 1 and country 2, whereas those between country 3 and the member countries of PTA are maintained.

It is assumed that there are three sectors in each country: the manufactured good sector, the intermediate component sector and the traditional good sector. The manufactured good sector produces many varieties of differentiated products while the traditional sector produces a homogenous traditional good. As discussed in more detail later, the production of varieties of the manufactured good is viewed as a sequence of transformations in which intermediate components are combined until a manufactured good is produced. Consider the traditional good as a numéraire, and the price of each product becomes the relative price against the traditional good. As a factor of production, only labor is employed, as in the Ricardian model. The representative consumer in each country has  $L_i$  units of labor and its labor supply is perfectly inelastic.

The following Cobb-Douglas utility function represents the consumer's preference for two types of goods:

$$U_i = \left( \sum_{s=1}^3 n_s x_{si}^\rho \right)^{\frac{\mu}{\rho}} Y_i^{1-\mu}. \quad (1)$$

The first part of the right-hand side of the equation is a constant elasticity of substitution (CES) function of many varieties of the manufactured good, where  $x_{si}$  denotes the consumption of each available variety from country  $s$  in country  $i$ ,  $n_s$  is the number of varieties produced in country  $s$ ,  $Y_i$  is the consumption of the traditional good in country  $i$ , and  $\mu$  is a constant representing the expenditure share of all the manufactured varieties. The parameter  $\rho$  represents the intensity of the preference for varieties of the manufactured good. When  $\rho$  is close to 1, differentiated goods are almost perfect substitutes. By contrast, when  $\rho$  becomes closer to 0, the desire to consume a greater number of varieties increases. If  $\sigma \equiv \frac{1}{1-\rho}$ , then  $\sigma$  represents the elasticity of substitution between any two varieties. From the definition,  $\sigma$  is greater than 1. The greater the value of  $\sigma$ , the substitutability between the varieties increases.

Given income  $I_i$  and the price of the manufactured good<sup>1</sup> relative to the numéraire good  $p_i^x$  in country  $i$ , the consumer's problem is to maximize utility (1) subject to the budget constraint,

$$Y_i + \sum_{s=1}^3 n_s p_s^x (1+t_{si}) x_{si} = I_i. \quad (2)$$

The importer of the manufactured good has to pay a certain percentage of the price of the manufactured good as the trade cost.  $t_{si}$  represents the trade cost rate for trading manufactured products from country  $s$  to  $i$ . This “trade cost rate” includes transportation cost, tariff and ad valorem equivalents of non-tariff barriers such as

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<sup>1</sup> In each country, each variety of the final good enters the utility function symmetrically and is produced under the same production technology. Thus, the price to consumers will be the same in each country.

quantitative restrictions and the so-called “iceberg” transport cost, which arises because a certain fraction of the shipments does not arrive (Helpman and Krugman, 1985, p. 206). This model assumes that no trade cost is incurred for trade between the two member countries and a positive trade cost is incurred for trade between the member and non-member countries (i.e.,  $t_{12} = t_{21} = 0$ ,  $t_{13} = t_{31} = t_{23} = t_{32} = t$ ). For simplicity, trade cost arises only for trading the manufactured product and not for trading traditional and intermediate goods.

Consumption demand in country  $i$  for a variety produced in country  $j$  follows as<sup>2</sup>

$$x_{ji} = [p_j^x(1+t_{ji})]^{-\sigma} G_i^{x\sigma-1} \mu I_i, \quad (3)$$

where  $G_i^x$  denote this by writing a price index of the manufactured good in country  $i$ :

$$G_i^x = \left\{ \sum_{s=1}^3 n_s [p_s^x(1+t_{si})]^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}. \quad (4)$$

Although the price of varieties varies with the location of production, this price index represents a general price level of the manufactured good in country  $i$ . It may take a different value in each country. Summing across countries in which the product is sold, the total demand of a single variety produced in country  $i$  is:

$$x_i = \sum_{s=1}^3 x_{is} = \sum_{s=1}^3 \frac{(G_s^x)^{\sigma-1} \mu I_s}{[p_i^x(1+t_{is})]^\sigma}. \quad (5)$$

Next, the behavior of manufactured good producers is considered. The production of the manufactured good only uses intermediate components as its inputs. The producer uses components depending on their relative unit costs across the three

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<sup>2</sup> See appendix for details.

countries. The unit cost of component  $k$  in country  $i$  is denoted by  $p_i^z[k]$ . The components used in production of the manufactured good can be divided into three groups. The first group (Group I) is a set of components that the unit cost is lowest in country 1. In a numerical formula, Group I satisfies the condition:  $p_1^z[k] \leq p_i^z[k]$ , where  $i \in \{2,3\}$ . Group II is a set of components that is cheapest in country 2, that is, Group II satisfies the condition:  $p_2^z[k] < p_1^z[k]$  and  $p_2^z[k] \leq p_3^z[k]$ . Finally, Group III is a set of components that is cheapest in non-member country 3. In other expression, Group III satisfies the condition:  $p_3^z[k] < p_j^z[k]$ , where  $j \in \{1,2\}$ . Hence, the manufactured good producers in each country initially employ components belonging to the first group in country 1, those in the second group in country 2 and those in the third group in non-member country 3. Components are indexed belonging to a continuum from  $[0,1]$ . The components in Group I are in the interval  $[0, \alpha]$ . Those of Group II are in the next interval  $(\alpha, \beta]$  and those of Group III are in the interval  $(\beta, 1]$ . Then, the unit cost of the manufactured good in country  $i$  is obtained as follows:

$$G_i^z = \int_0^\alpha p_1^z[k] dk + \int_\alpha^\beta p_2^z[k] dk + \int_\beta^1 p_3^z[k] dk \quad (6)$$

Finally, the production function for the traditional goods is supposed as linear in output:  $q_i^y = (1 - \lambda_i)L_i$ , where  $\lambda_i$  is the share of labor input used for intermediate components production in country  $i$ . This implies that the wage in the traditional sector is unity. Following Martin and Rogers (1995), wage differences among countries are not introduced in this paper. Had technology difference across countries been set up, e.g.,  $q_i^y = A_i(1 - \lambda_i)L_i$ , it would be possible to introduce the wage difference in this analysis.

### 3. MARKET EQUILIBRIUM

Next, the conditions for general equilibrium and firm location under equilibrium are investigated. From the assumption on the production technology for traditional good, the wage in the traditional sector is unity. Therefore, as long as there is some employment for the traditional good sector in a country, the equilibrium wage for the intermediate component sector is also equal to unity in the country.

Now the level of demand for intermediates is assumed to be small enough and ensures that each country has some traditional goods even if all intermediates is concentrated in a single country. Then equilibrium wages in all countries are ensured to be unity. Intermediate sectors can draw labor from traditional sector at a constant wage.

The income in each country is therefore

$$I_i = w_i \lambda_i L_i + (1 - \lambda_i) L_i = L_i . \quad (7)$$

The income level is now determined by the exogenous variable, the labor endowment. The required equations for the general equilibrium are this income determination equation and the market clearing condition for each sector and labor market.

The market clearing condition for the manufactured good is

$$q_i^{x*} = \sum_{s=1}^3 \frac{(G_s^x)^{\sigma-1} \mu I_s}{[p_i^x (1 + t_{is})]^\sigma} . \quad (8)$$

For intermediate good market, the clearing conditions are

$$\int_0^\alpha q_1^z[k] dk = \alpha \sum_{i=1}^3 n_i ,$$

$$\int_\alpha^\beta q_2^z[k] dk = (\beta - \alpha) \sum_{i=1}^3 n_i , \text{ and}$$

$$\int_{\beta}^1 q_3^z[k] dk = (1 - \beta) \sum_{i=1}^3 n_i. \quad (9)$$

For the traditional good sector,

$$\sum_{i=1}^3 Y_i = \sum_{i=1}^3 q_i^y \quad \text{or} \quad \sum_{i=1}^3 (1 - \mu) I_i = \sum_{i=1}^3 (1 - \lambda_i) L_i. \quad (10)$$

Finally, the equilibrium conditions for the labor market in each country is

$$\begin{aligned} L_1 &= \sum_{s=1}^3 n_s \int_0^{\alpha} p_1^z[k] dk + (1 - \lambda_1) L_1, \\ L_2 &= \sum_{s=1}^3 n_s \int_{\alpha}^{\beta} p_2^z[k] dk + (1 - \lambda_2) L_2, \text{ and} \\ L_3 &= \sum_{s=1}^3 n_s \int_{\beta}^1 p_3^z[k] dk + (1 - \lambda_3) L_3. \end{aligned} \quad (11)$$

Now the location of the manufactured good producers is simulated using the above equilibrium conditions. This simulation sets the expenditure share of manufactured goods on the following assumption ( $\mu=0.3$ ). The labor endowment and the unit cost of the manufactured good are set as unity to simplify the simulation.

Table 1. Location of Manufactured Good Producers

$\sigma$	trade cost	$n_1=n_2$	$n_1+n_2$	$n_3$	$n_1+n_2+n_3$
2	1.0	0.375	0.750	0.000	0.750
	2.0	0.313	0.625	0.125	0.750
	3.0	0.298	0.595	0.170	0.745
3	1.0	0.315	0.630	0.180	0.810
	2.0	0.298	0.595	0.245	0.840
	3.0	0.296	0.593	0.268	0.860
4	1.0	0.304	0.607	0.243	0.850
	2.0	0.298	0.597	0.282	0.879
	3.0	0.299	0.598	0.292	0.890

$\sigma$ : the elasticity of substitution between any two varieties.  
 $n_i$ : the number of varieties produced in country  $i$ .

Table 1 indicates that the lower the trade costs, the fewer is the number of varieties in the non-member country and the greater is the number of varieties in the

PTA member countries. Moreover, the smaller the elasticity of substitution between any two varieties ( $\sigma$ ), the greater is the reduction in the number of varieties in the non-member country. The number of varieties in the PTA member countries, however, appears to be negatively correlated with the value of  $\sigma$ .

#### **4. EFFECTS OF RULES OF ORIGIN**

Now the effects of rules of origin are analyzed. Rules of origin are the criteria to determine whether any particular product is made in the PTA member country. When the firm that is forced on rules of origin (e.g., a certain minimum spending on domestic components must be embodied in the total cost of the product) does not follow them, the product is treated as a non-member good even when it is produced in the final stage in a member country. The firm has to pay a penalty tariff to trade its product to other member countries.

In the case that the rules of origin are too strict to ignore, the manufactured good producers who are enforced the rules have only two choices: to obey or not to obey the rules. If the firm decides to obey the rules, it has to increase the share of the usage of the local components. By conforming to the rules, the penalty can be avoided because its products are treated as local products. By contrast, if the firm decides not to abide by the rules, it must pay the discriminated penalty tariff.

Now consider the impact of enforcing rules of origin. The rule of origin in this model requires member country components to be a certain physical ratio of total components. Let us say the required physical content ratio is  $\gamma$  ( $0 < \gamma \leq 1$ ). On the

one hand, if the content requirement ratio is small enough not to conflict on the previous optimal choice of components (so that  $0 < \gamma \leq \beta$ ), rules of origin do not affect trade in components with the non-member country. Therefore, the producer of the manufactured good does not have to alter the choice of components in order to gain access to duty free components from the member country. However, if a content requirement greater than the initial level is introduced through rules of origin, some additional components must originate in the members of the PTA.

On the other hand, if the content requirement is large enough to compel manufactured good producers to employ the local components more than the previous optimal level (so that  $\beta < \gamma < 1$ ), the components in the interval  $(\beta, \gamma]$  must originate within the PTA. In the interval  $(\beta, \gamma]$ , the manufactured good producer compares the unit cost of the components within the member countries. Suppose that the producer of the manufactured good now uses components in the interval  $(\beta, \phi)$  from country 2 and components in the interval  $[\phi, \gamma]$  from country 1. Only components in the interval  $(\gamma, 1]$  will be imported from the non-member country 3. The producer of the manufactured good employs components of the PTA members in the interval  $(\beta, \gamma]$ , even though the components from the non-member country are relatively cheap. Therefore, the marginal cost or unit cost of production would increase because of the distortion introduced by the rules of origin and the discriminatory tariff.

#### **4.1 The case of not following the rules of origin**

In this case, the unit cost of the production for the manufactured good producer does not change at all. It means that the price of each variety of the manufactured good does not change. However, the trade cost among member countries of the PTA increases

as the penalty resulting from not obeying the rules of origin increases ( $\forall t_{ij} = t$ ,  $i, j \in \{1,2,3\}$ ). The general price level or price index of the manufactured good also increases because of the increase in the trade cost between member countries.

Now, the effect of an increase in the trading cost among member countries on the firm location are simulated using the manufactured good market equilibrium condition. The results of simulation are shown in Table 2.

Table 2. Location Effect of Refusing Rules of Origin

$\sigma$	trade cost	$n_1=n_2$	$n_1+n_2$	$n_3$	$n_1+n_2+n_3$
2	1.0	0.225	0.450	0.225	0.675
	2.0	0.220	0.440	0.220	0.660
	3.0	0.225	0.450	0.225	0.675
3	1.0	0.250	0.500	0.250	0.750
	2.0	0.264	0.527	0.264	0.791
	3.0	0.275	0.550	0.275	0.825
4	1.0	0.270	0.540	0.270	0.810
	2.0	0.286	0.572	0.286	0.859
	3.0	0.293	0.586	0.293	0.880

$\sigma$ : the elasticity of substitution between any two varieties.  
 $n_i$ : the number of varieties produced in country  $i$ .

Table 2 shows that the trade cost would increase attributable to the discriminated tariff, and the world looks like the situation before forming the PTA. The number of firms in the non-member country would increase.

#### 4.2 The case of following the rules of origin

The next argument concerns the case where the manufactured good producers in the PTA follow the rules of origin. By following the rules of origin, the new unit cost of the production would become as follows:

$$g_i^z = \int_0^\alpha p_1^z[k]dk + \int_\alpha^\phi p_2^z[k]dk + \int_\phi^\gamma p_1^z[k]dk + \int_\gamma^1 p_3^z[k]dk . \quad i \in \{1,2\}. \quad (12)$$

By contrast, the manufactured good producers in the non-member country has the same level of the previous unit cost since the rules of origin does not affect them.

Note that rules of origin make the local firms within the PTA pay higher unit cost of the production than the non-member firms. This affects the prices of the varieties: i.e., the varieties produced in the PTA become more expensive than the varieties produced in the non-member country.

Table 3 summarizes the results of the simulation for the effects on the location of the manufactured good producers using the market equilibrium conditions.

Table 3. Location Effect of Rules of Origin

$\sigma$	trade cost	unit cost	$n_1=n_2$	$n_1+n_2$	$n_3$	$n_1+n_2+n_3$
2	1.0	1.0	0.375	0.750	0.000	0.750
		1.1	0.282	0.564	0.147	0.711
		1.2	0.202	0.405	0.271	0.676
		1.3	0.128	0.255	0.389	0.644
	2.0	1.0	0.313	0.625	0.125	0.750
		1.1	0.263	0.526	0.183	0.709
		1.2	0.222	0.443	0.230	0.673
		1.3	0.186	0.371	0.270	0.641
3	1.0	1.0	0.315	0.630	0.180	0.810
		1.1	0.259	0.518	0.247	0.765
		1.2	0.211	0.421	0.304	0.725
		1.3	0.165	0.330	0.358	0.689
	2.0	1.0	0.298	0.595	0.245	0.840
		1.1	0.262	0.524	0.267	0.791
		1.2	0.232	0.465	0.284	0.749
		1.3	0.206	0.413	0.299	0.712

$\sigma$  : the elasticity of substitution between any two varieties.

$n_i$ : the number of varieties produced in country  $i$ .

Table 3 shows that the restrictive rules of origin reduce the number of varieties within the PTA and increase those in the non-member country. The reason for this is that

stricter rules of origin increase the unit costs of production only within the PTA and cause the varieties in the non-member country to be relatively less expensive. This phenomenon is conspicuous with lower trade costs or lower substitutability between the varieties. In addition, the total number of varieties,  $n_1 + n_2 + n_3$ , decreases with stricter rules of origin.

## 5. THE EFFECTS ON PRICES AND WELFARE

Finally, the effects of the rules of origin on prices and welfare are investigated. The indirect utility function from the consumer's utility maximization is expressed as follows:

$$V_i = \mu^\mu (1 - \mu)^{1-\mu} \frac{I_i}{(G_i^x)^\mu}. \quad (13)$$

The term  $(G_i^x)^\mu$  can be regarded as indicator of the cost for living in country  $i$ . Thus, the level of the real income is measured by the price index of the manufactured good.

Four cases are simulated and their results are summarized in Table 4. Case I supposes that any rules of origin do not exist or they are too lax to control the producers' behavior. Case II assumes that the firms in the PTA decide not to follow the rules of origin. Case III is based on the assumption that the rules of origin are so strict that the unit cost of the production increases more than the previous level, e.g. 1.1. Finally, Case IV assumes that the rules of origin are stricter than that in Case III, e.g. the unit cost of production becomes 1.2.

Table 4. Welfare Effects of Rules of Origin

Cases	unit cost	$G_1^x = G_2^x$	$G_3^x$	$V_1 = V_2$	$V_3$
I	1.0	1.217	1.721	0.512	0.461
II	1.0	1.633	1.633	0.469	0.469
III	1.1	1.429	1.680	0.488	0.465
IV	1.2	1.647	1.629	0.467	0.469

$G_i^x$ : the price index of the manufactured good in country  $i$ .

$V_i$ : the level of the indirect utility function in country  $i$ .

Assuming  $t$  (trade cost) = 1 and  $\sigma$  (elasticity of substitution) = 3.

Table 4 indicates that in Case II (not following rules of origin) the price level of the manufactured products increases within the PTA and the welfare level of the member countries decreases. This is because the products do not receive preferential treatment although they are produced within the PTA. Similarly, in Cases III and IV (following rules of origin), an increase in the unit cost of the production owing to the stricter rules of origin increases the price level of the manufactured products within the PTA and consequently reduces the welfare level of the member countries. As a result, rules of origin reduce the real income and welfare within the PTA whether following the rules or not. By contrast, in the non-member country the price level of the varieties decreases and the welfare level increases. This is because rules of origin increase the number of firms and varieties in the non-member country as has been explained in the previous section. An increase in the domestic varieties brings about a reduction in payments for trade costs to consumers in the non-member country. Consequently, the rules of origin increase the real income and welfare in the non-member country.

## 6. CONCLUSION

Rules of origin do not always bring benefits to the nations that enact them. On the contrary, the preceding analysis indicates that stricter rules of origin make the consumers in the member countries of the PTA worse off. Restrictive rules of origin impose the manufactured good producers within the PTA to choose between following the rules and accepting the discriminated tariff on their products. This compulsion of the choice increases the price of varieties in the PTA after all regardless of the firms' choice.

The increase in the cost of the production only in the PTA owing to the strict rules of origin brings the firms in the non-member country an advantage in costs. Therefore, the number of firms or varieties decreases within the PTA and increases outside of the PTA. The reduction in the number of varieties within the PTA worsens the welfare in the PTA and may also lead to a negative welfare effect in the non-member country. The increase in the number of the varieties outside the PTA, however, offsets the welfare loss of the non-member country to a certain extent.

As the policy implication of this analysis, the "optimal" rules of origin, which lead to the highest welfare for each member country of the PTA, would be achievable if they are sufficiently low that they do not distort the decision of the manufactured good producers. Furthermore, this optimal rule of origin also keeps the total number of varieties or firms the largest level and leads the highest welfare for non-member countries of the PTA.

A foreseeable extension of this research would be to include the behavior of intermediate component producers. The location of the intermediate good sectors does not affect the welfare in the present model. However, it is natural to suspect that the

varieties of intermediate components would grow within a PTA when manufactured good producers follow restrictive rules of origin. If the market of the intermediate components and trade costs on their transactions were incorporated in the model, the results of welfare effects would have been more favorable to member countries and harsher to non-member countries.

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## APPENDIX

### Consumer behavior

The utility maximization problem for each consumer is:

$$U_i = Y_i^{1-\mu} X_i^\mu, \text{ where } X_i = \left( \sum_{s=1}^3 n_s x_{si}^\rho \right)^{\frac{1}{\rho}}$$

$$\text{s.t. } Y_i + \sum_{s=1}^3 n_s p_s^x (1+t_{si}) x_{si} = I_i.$$

This problem can be solved in two steps. The first step is cost minimization problem.

$$\min \sum_{s=1}^3 n_s p_s^x (1+t_{si}) x_{si}, \text{ s.t. } \left[ \sum_{s=1}^3 n_s x_{si}^\rho \right]^{\frac{1}{\rho}} = X_i$$

The first-order condition to this cost minimization problem gives the marginal rate of substitution between two varieties equals to their price ratio.

$$\frac{x_{ji}^{\rho-1}}{x_{ii}^{\rho-1}} = \frac{p_j^x (1+t_{ji})}{p_i^x (1+t_{ii})}.$$

$$\text{This gives } x_{ji} = \left( \frac{p_j^x (1+t_{ji})}{p_i^x (1+t_{ii})} \right)^{\frac{1}{\rho-1}} x_{ii}.$$

Substituting this equation into the original constraint,

$$\left[ \sum_{s=1}^3 n_s \left( \frac{p_s^x (1+t_{si})}{p_i^x (1+t_{ii})} \right)^{\frac{\rho}{\rho-1}} x_{ii}^\rho \right]^{\frac{1}{\rho}} = X_i$$

and bringing the common term,  $x_{ii} \left( \frac{1}{p_i^x (1+t_{ii})} \right)^{\frac{1}{\rho-1}}$ , outside, the compensated demand

function for the manufactured goods from country  $i$  given the sub-utility function,  $X_i$  would be obtained.

$$x_{ii} \left( \frac{1}{p_i^x (1+t_{ii})} \right)^{\frac{1}{\rho-1}} \left[ \sum_{s=1}^3 n_s [p_s^x (1+t_{si})]^{\frac{\rho}{\rho-1}} \right]^{\frac{1}{\rho}} = X_i$$

$$\text{or } x_{ii} = \frac{[p_i^x (1+t_{ii})]^{\frac{1}{\rho-1}}}{\left[ \sum_{s=1}^3 n_s [p_s^x (1+t_{si})]^{\frac{\rho}{\rho-1}} \right]^{\frac{1}{\rho}}} X_i.$$

An expression for the minimum cost of attaining  $X_i$  is also able to be derived using the above the compensated demand equations:

$$\sum_{s=1}^3 n_s p_s^x (1+t_{si}) x_{si} = \left\{ \sum_{s=1}^3 n_s [p_s^x (1+t_{si})]^{\frac{\rho}{\rho-1}} \right\}^{\frac{\rho-1}{\rho}} X_i.$$

The term multiplying  $X_i$  on the right-hand side of this expression is defined as a price index times the quantity composite is equal to cost. Denoting this price index of the manufactured good in country  $i$  by  $G_i^x$  gives

$$G_i^x = \left\{ \sum_{s=1}^3 n_s [p_s^x (1+t_{si})]^{\frac{\rho}{\rho-1}} \right\}^{\frac{\rho-1}{\rho}} = \left\{ \sum_{s=1}^3 n_s [p_s^x (1+t_{si})]^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}.$$

The compensated demand functions  $x_{si}$  can now be written more compactly as

$$x_{si} = \left( \frac{p_s^x (1+t_{si})}{G_i^x} \right)^{\frac{1}{\rho-1}} X_i = \left( \frac{p_s^x (1+t_{si})}{G_i^x} \right)^{-\sigma} X_i.$$

The second step of the consumer's problem is to divide total income between traditional and manufactured goods in aggregate, that is, to choose  $Y_i$  and  $X_i$  so as to

$$\max U_i = X_i^\mu Y_i^{1-\mu} \quad \text{s.t.} \quad G_i^x X_i + Y_i = I_i.$$

From the first-order condition, Marshallian demand functions are obtained.

$$X_i = \frac{\mu I_i}{G_i^x} \quad \text{and} \quad Y_i = (1-\mu) I_i.$$

The Marshallian demand function for each variety of manufactures is

$$x_{ji} = [p_j^x (1 + t_{ji})]^{-\sigma} (G_i^x)^{\sigma-1} \mu I_i.$$

Now the indirect utility function is expressed as follows:

$$V_i[G_i^x, I_i] = \mu^\mu (1 - \mu)^{1-\mu} \frac{I_i}{(G_i^x)^\mu}.$$

From the Marshallian demand function, the total demand of a single variety produced in country  $i$  is:

$$x_i = \sum_{s=1}^3 x_{is} = \sum_{s=1}^3 \frac{(G_s^x)^{\sigma-1} \mu I_s}{[p_i^x (1 + t_{is})]^\sigma}.$$

### Manufactured good producer behavior

The profit maximization problem for the manufactured good producer is:

$$\max \pi_i^x = p_i^x q_i^x - G_i^z (F + c q_i^x),$$

where  $G_i^z = \int_0^\alpha p_1^z[k] dk + \int_\alpha^\beta p_2^z[k] dk + \int_\beta^1 p_3^z[k] dk$ .

The profit maximization implies that

$$p_i^x \left(1 - \frac{1}{\sigma}\right) = c G_i^z \quad \text{or} \quad p_i^x = \frac{c G_i^z}{\rho},$$

for all varieties produced in country  $i$ .

Suppose that there are free entry and exit in response to profits or losses. Given the pricing rule, the profits of a firm in country  $i$  are

$$\pi_i^x = G_i^z \left( \frac{c q_i^x}{\sigma - 1} - F \right)$$

Under zero profit condition, the supply of each variety can be derived as:

$$q_i^{x*} = \frac{F(\sigma - 1)}{c}.$$