I. Introduction

How does reducing tariff rates multilaterally affect the world growth rate under increasing globalization characterized by active mobility in the international relocation of production by firms? This paper examines whether simultaneous multilateral tariff reductions can increase the world growth rate when firms are freely mobile across countries and technical knowledge from research and development (R&D) is a regionally limited local public good.

Over the past four decades, with the increase in the number of the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO) members, the resulting global reduction in tariff rates, and the global relaxation of regulations on the cross-border entry of foreign firms into other countries, there has been a sharp increase in international trade activity associated with the cross-border relocation of firms. However, although there is a large body of empirical evidence showing that international relocation and foreign direct investment by firms are important channels for technological knowledge transfer (e.g., Coe and Helpman, 1995; Keller, 1998, 2002, 2004; Klenow and Rodriguez-Clare, 2004; Park, 2004; Zhu and Nam Jeon, 2007), the impact of tariff reductions on cross-border relocation of firms has been overlooked in the theoretical work on the relationship between tariffs and economic growth.
growth in the endogenous growth literature (e.g., Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991a, 1991b; Osang and Pereira, 1996; Ben-David and Loewy, 2000; Dinopoulos and Segerstrom, 1999a, 1999b; Osang and Turnovsky, 2000; Peretto, 2003; Chen, Lee, and Shimomura, 2009). Thus, it is necessary to examine how a multilateral tariff rate reduction affects economic growth through the relocation of firms and the associated technological knowledge spillovers using an endogenous growth model. In fact, although there are many theoretical studies in the endogenous growth literature on the growth effects of tariffs using a small open economy model or a symmetric multi-country economy model, because in both approaches the production location of firms is internationally fixed, there are few theoretical studies that analyze the world growth effects of a simultaneous reduction in the tariff rate of all countries using a two-country endogenous growth model with international relocation of firms.\(^1\)

As a different approach to the above studies, a large body of work in the new economic geography literature examines the relationship between transport costs, including transaction or trade costs, and economic growth. Important studies in this area include Martin (1999), Baldwin (1999), Martin and Ottaviano (1999, 2001), Baldwin and Forslid (2000), Baldwin, Martin, and Ottaviano (2001), Baldwin, Braconier, and Forslid (2005), and Fukuda (2017). For example, Martin and Ottaviano (1999) analyze the impact of trade cost reductions (or trade openness) through iceberg-type transport cost reductions on the global growth rate through their effect on industrial location. However, the above literature is essentially a two-region model of a closed economy with no tariffs applicable within the European Union, and thus the problem remains that the relationship between cross-border firm relocation and tariff rates has not been explicitly considered. This is because in the authors' model, using two regions within a single country, one cannot help but assume that transport costs are the only barrier to trade in these models.

In contrast, our paper first extends the two-region endogenous growth model of Martin and Ottaviano (1999) to an open economy model and then examines the impact of a simultaneous multilateral tariff reduction on the world growth rate by introducing import tariffs into this model. This model has two countries in which knowledge spillovers are assumed to depend positively on the number of firms located in that country, and the spillovers occur only within the geographical area of each country. Because of these localized knowledge spillovers, the cost of innovation in a given country falls as the total number of firms in that country increases. Therefore, from this model, we obtain the result that if a simultaneous multilateral tariff reduction increases the concentration of firms in the larger home country, then the world growth rate will be boosted by the reduction in R&D costs due to the increase in localized knowledge.

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1) In the endogenous growth literature, for the small open economy model, the studies by Osang and Pereira (1996) and Osang and Turnovsky (2000) are well-known theoretical studies on the relationship between tariffs and growth. For the symmetric multi-country model, the studies of Rivera-Batiz and Romer (1991a, 1991b), Dinopoulos and Segerstrom (1999a, 1999b), Peretto (2003), and Ourens (2016) are well-known theoretical studies.
spillovers in R&D in the home country.\textsuperscript{2)}

The remainder of the paper is structured as follows. Section II outlines the features of the model. Section III describes the equilibrium location and firm size, respectively, and Section IV details the R&D sector. Section V examines the impact of a simultaneous multilateral tariff reduction on the world growth rate. Section VI examines the impact of a simultaneous multilateral reduction in tariffs on the welfare of the individual countries. Section VII concludes the paper.

\section{Model Structure}

We develop a two-country model consisting of home and foreign locations. The models for the home and foreign countries are identical, apart from their initial stock of capital. We use an asterisk to denote the variables for the foreign country. In the following, we focus mainly on a description of the home country, because it is equivalent to the foreign country. Unlike households as owners of firms, firms are internationally mobile.

The objective of a representative household is to maximize the following lifetime utility function:

\[ U = \int_0^{\infty} \log \left[ D(t)^{\rho} Y(t) \right] e^{-\rho t} dt, \] (1)

where \( \rho \) is the subjective discount rate, \( Y(t) \) is the numeraire good in period \( t \), and \( D(t) \) is the consumption index of differentiated goods. In this model, \( D(t) \) is defined as follows:

\[ D(t) = \left[ \int_{i=0}^{N(t)} D_i(t)^{1-1/\sigma} \right]^{1/(1-1/\sigma)}, \quad \sigma > 1, \] (2)

where \( \sigma \) is the elasticity of substitution between any two differentiated goods, \( D_i(t) \) is the consumption of differentiated good \( i \), and \( N(t) \) is the total number of differentiated goods produced in both the home and foreign countries. In this model, the home government imposes an import tariff on the imported differentiated consumption goods and transfers the tariff revenue to households as a lump sum. However, for simplicity, there is no tariff on the numeraire good. Furthermore, following the conventional setup in the new economic geography literature,\textsuperscript{2)} As the other related studies on the relationship between knowledge spillovers and economic growth in open economy endogenous growth models, Goo and Lee (2002) and He (2017) examine the impact of technological knowledge spillovers through trade on the economic growth of each country.
we assume iceberg transport costs in shipping the differentiated goods between countries. Specifically, \( \tau > 1 \) units of a differentiated good are shipped from the foreign (home) country to the home (foreign) country for one unit to arrive at its destination. The time subscript is omitted. Per capita expenditure, \( E \), is then given as follows:

\[
\int_{i \in a} p_i D_i d_i + \int_{j \in a} (1 + \tau_h) \tau p_j^* D_j d_j + Y = E, \tag{3}
\]

where \( \tau_h (\tau_f) \) is the tariff rate of the home (foreign) country. In this model, the home country consists of \( n \) firms and the remaining \( n^* \) firms are in the foreign country, and \( n + n^* = N \) holds at each point in time. \( p_i \) is the producer price of a typical variety \( i \) in the home country and \( p_j^* \) is its price in the foreign country. The consumption price indices for the differentiated products are then:

\[
P^D = \left( \int_{i \in a} p_i^{1 - \sigma} d_i + \int_{j \in a} (1 + \tau_h) \tau p_j^* \right)^{\frac{1}{1 - \sigma}}, \tag{4}
\]

\[
P^{D*} = \left( \int_{i \in a} (1 + \tau_f) \tau p_i \right)^{\frac{1}{1 - \sigma}} + \int_{j \in a} p_j^{1 - \sigma} d_j \right)^{\frac{1}{1 - \sigma}}, \tag{5}
\]

where \( P^D (P^{D*}) \) is the price index in the home (foreign) country. In the differentiated goods sector, a patent is required to start producing each variety of good, so we can interpret this capital requirement as a fixed cost of production. Each firm issues equities to finance the fixed cost of the patent and distributes all profits to shareholders as dividends. In addition, each good requires \( \beta \) units of labor. Standard profit optimization by choosing \( p_i \) gives \( p_i = w \beta / (\sigma - 1) \). The profit flow of each firm in the differentiated goods sector \( (= \pi_i) \) is then:

\[
\pi_i = p_i x_i(p_i) - w \beta x_i(p_i) = w \beta x_i(p_i) / (\sigma - 1), \tag{6}
\]

where \( x_i(p_i) \) is the quantity of output. The homogeneous good \( Y \) is assumed to be produced using some constant returns to scale technology that requires labor as the only input, where firms use one unit of labor to produce one unit of \( Y \). We also assume that some production of the homogeneous good occurs in both countries. Thus, we ensure factor-price equalization across countries \( w = w^* \) at any point in time due to free trade in the homogeneous good. As the numeraire is the homogeneous good, the wage rate in each location is \( w = w^* = 1 \). We therefore obtain \( p = p^* = \beta / (\sigma - 1) \). Here, we define \( \delta = \tau^{1-\sigma} (0, 1) \) for convenience, consistent with the new economic geography literature.
From standard utility optimization, given the choice of \( D_i, D_j, \) and \( Y \), each household spends a constant fraction \( \alpha \) of its consumption expenditure \( E \) on the differentiated goods and the remaining \( (1 - \alpha) \) of \( E \) on good \( Y \):

\[
D_i = \left( \frac{\sigma - 1}{\beta \sigma} \right) \frac{a E}{n + n^* (1 + \tau_h)^{1-\delta}}, \quad D_j = \left( \frac{\sigma - 1}{\beta \sigma} \right) \frac{a E (1 + \tau_h)^{-\delta}}{n + n^* (1 + \tau_h)^{1-\delta}}, \quad Y = (1 - \alpha)E
\]  

(7)

Here, we define \( v \) as the equity value of a firm and \( r \) as the return on a riskless bond. A no-arbitrage condition in capital markets relates the expected return on equity to the return on an equally sized investment in the riskless bond. Therefore, by considering (6), we obtain \( \beta x / (\sigma - 1) + \dot{v} = rv \). The maximization of (1) subject to the intertemporal budget constraint and free capital mobility between countries requires that nominal expenditures grow at an instantaneous rate equal to \( r - \rho \): \( \ddot{E}/E = \ddot{E}^*/E^* = r - \rho \). Consequently, if there is a balanced growth path, then nominal expenditure must be constant and hence \( r = \rho \).

III. Firm Sizes and Locations

Here, we determine firm sizes \( (x, x^*) \) and locations \( (n, n^*) \) for given levels of expenditures \( (E, E^*) \). Aggregating the demands in (7) across all households worldwide, we obtain the following market-clearing condition for any differentiated product \( x \):

\[
x = \frac{a L (\sigma - 1)}{\beta \sigma} \left( \frac{E}{n + n^* (1 + \tau_h)^{1-\delta}} + \frac{E^* (1 + \tau_f)^{-\delta}}{n^* + n (1 + \tau_f)^{1-\delta}} \right),
\]  

(8)

where \( L \) is the amount of labor endowment. Similarly, for any product \( x^* \), we obtain:

\[
x^* = \frac{a L (\sigma - 1)}{\beta \sigma} \left( \frac{E (1 + \tau_h)^{-\delta}}{n + n^* (1 + \tau_h)^{1-\delta}} + \frac{E^*}{n^* + n (1 + \tau_f)^{1-\delta}} \right).
\]  

(9)

The model assumes that firms do not face any relocation costs, so that relocation does not take any time. For a firm to be indifferent between the home and the foreign locations following location arbitrage, the operating profits from the two locations must also be equal: \( \pi = \pi^* \). Therefore, from the equations \( \pi = w \beta x / (\sigma - 1) \), \( \pi = \pi^* \), and \( w = w^* = 1 \), we obtain \( x = x^* \).
Let \( K \) and \( K^* \) be the capital stocks in the home and the foreign countries, respectively. Furthermore, the total stock of capital owned by agents determines the total number of firms, such that: \( n + n^* = K + K^* = N \). Solving (8), (9), \( \pi = \pi^* \) and \( n + n^* = N \) for a given level of expenditure \((E, E^*)\), we obtain the share of firms in the home country, where we define \( \gamma \) as:

\[
\gamma = \frac{n}{N} = \frac{\left(1 + \tau_f\right)^{-\sigma \delta - 1} \left(1 + \tau_h\right)^{1 - \sigma \delta} E^* - \left(1 + \tau_h\right)^{-\sigma \delta - 1} E}{\overline{E}}
\]

where \( \overline{E} = \left(1 + \tau_h\right)^{-\sigma \delta - 1} \left(1 + \tau_f\right)^{1 - \sigma \delta - 1} E + \left(1 + \tau_f\right)^{-\sigma \delta - 1} \left(1 + \tau_h\right)^{1 - \sigma \delta - 1} E^* \).

In the following, we assume a common tariff rate, so that we obtain \( \tau_h = \tau_f = \tau_c \). Then, equation (10) is rewritten as follows:

\[
\gamma = \frac{n}{N} = \frac{\left(1 + \tau_c\right)^{1 - \sigma \delta} E^* - E}{\left(1 + \tau_c\right)^{1 - \sigma \delta - 1} E + \left(1 + \tau_c\right)^{1 - \sigma \delta - 1} E^*}.
\]

As in Martin (1999) and Martin and Ottaviano (1999), which assume \( K > K^* \), we also assume \( K > K^* \) in our model. Under this assumption, more international firms locate in the home country than in the foreign country in our model too. This is because a higher capital stock in the home country than in the foreign country implies \( E > E^* \), and thus more firms try to relocate their production location to the home country from the foreign country, both to avoid the burden of transport costs associated with exporting and to take advantage of increasing returns to scale in the differentiated goods sector. Therefore, assuming \( K > K^* \), the home country with its larger capital stock will have a higher concentration of firms. From equation (11), for a given level of expenditure \((E, E^*)\), we then obtain:

\[
\left. \frac{\partial \gamma}{\partial \tau_c} \right|_{\tau_f = 0} = \frac{\delta (\sigma - 1) (E^* - E)}{(1 - \delta)^2 (E + E^*)}.
\]

Equation (12) implies that a reduction in the common tariff rate of both countries induces the global relocation of firms to the home (foreign) country if \( E > (<) E^* \). An intuitive explanation for this result is as follows. First, when common tariff rates are lowered, firms will put more emphasis on the relative market size of each country when deciding where to locate, because even if tariff rates are lowered, transport costs remain constant and thus the differences in the relative market size of each country will be more critical in determining where to locate
due to the firms' motive based on reducing transport costs. Therefore, in the case where \( E > E^* \), a reduction in tariff rates will lead to a further increase in the relative profits of home-located firms through increasing returns to scale in the differentiated goods sector in the home country, and consequently foreign firms will relocate to the home country. Conversely, in the case where \( E < E^* \), the opposite mechanism occurs, and the global relocation of firms occurs from the home country to the foreign country.

The level of production of each firm is:

\[
x \cdot \bar{x} = \frac{aL(\sigma-1)}{\beta\sigma} \left[ \frac{1 + \tau_c}{(1 + \tau_c)^{2(1-\sigma)\delta^2} - 1} \right]^{\delta} \frac{1}{(1 + \tau_c)^{2(1-\sigma)\delta^2} - 1} \frac{1}{(1 + \tau_c)^{\delta - 1}} \cdot \tag{13}
\]

IV. R&D Sector with Local Spillovers

We now consider the R&D sector. We assume that forward-looking researchers decide on the level of R&D investment and that R&D technology is linear, where the invention of a new good is directly proportional to the amount of labor devoted to the activity. To consider the incentive for researchers to engage in innovative R&D, let \( \nu \) denote the value of a blueprint developed through innovative R&D. Following Martin and Ottaviano (1999), we assume that the cost of R&D in a location is negatively proportional to the number of firms already located in that location, where a researcher performing R&D uses \( \eta/n \) units of labor in the home country and \( \eta/n^* \) units in the foreign country. This implies that if the number of firms producing in the home country differs from the number of firms producing in the foreign country, all R&D activity will occur in the location with the larger number of firms. In our model, the larger capital stock in the home country (\( K > K^* \)) leads to higher real expenditure on differentiated goods in the home country than in the foreign country. Therefore, because firms relocate to the home country with higher real expenditure both to avoid the burden of transport costs associated with exporting and to take advantage of increasing returns to scale in the differentiated goods sector, the home country (with its higher capital stock) ends up with a higher concentration of firms than the foreign country. As a result, R&D costs in the home country become relatively low, so all R&D activity takes place in the home country, and this determines the global growth rate. Free entry into the R&D sector therefore gives \( \nu = \eta/n \).

In this section, we derive the solution for a steady state in which the share of firms in the home country and the growth rate of \( N \) do not change (i.e., \( \gamma = n/N \) and \( g = \dot{N}/N \) are constants). As the equity value of each firm is equal to the value of the blueprint it owns, the equity value of any firm \( \nu \) is determined by the free-entry condition in the R&D sector:
$v = \eta N \gamma$. If there is a balanced growth path, this implies that $v$ decreases at rate $g = \dot{N}/N = \dot{n}/n$. The world labor market-clearing condition is:

$$\eta \frac{g}{\gamma} + (1 - \alpha) L (E + E^*) + a L \left( \frac{\sigma - 1}{\sigma} \right) E^T = 2L,$$

(14)

where $\overline{T} = \left[ (1 + \tau_c)^{-2\delta^2 - 1} \right] / \left[ (1 + \tau_c)^{2(1 - \sigma) \delta^2 - 1} \right] \left[ (1 + \tau_c)^{-\sigma \delta - 1} \right]^2$. If both $g$ and $\gamma$ are constant in the steady state, then equation (14) implies that expenditures $E$ and $E^*$ must be constant. This leads to $r = \rho$ from $\dot{E}/E = \dot{E}^*/E^* = r - \rho$. Then, substituting equation (13), $v = \eta N \gamma$, and $r = \rho$ into equation $\beta x/(\sigma - 1) + \dot{\nu} = rv$ yields the following equilibrium growth rate of $K$, $K^*$ and $N$:

$$g = \frac{2L \gamma}{\eta \sigma} \frac{(1 - \alpha) L \gamma (E + E^*)}{\eta \sigma} - \left( \frac{\sigma - 1}{\sigma} \right) \rho,$$

(15)

where

$$E = 1 + \frac{\rho \eta k}{\gamma L} + \frac{\tau_c \tau n^* p^*_f D_f}{L},$$

(16)

$$E^* = 1 + \frac{\rho \eta (1 - k)}{\gamma L} + \frac{\tau_c \tau n p^*_h D_h^*}{L},$$

(17)

where $k = K/N$. Here, we assume for simplicity that $\chi_c \equiv \alpha \tau_c (1 + \tau_c)^{-\sigma \delta} \approx 0$. Intuitively, if $\sigma$ and $\tau$ are sufficiently large, and $\alpha$, and $\tau_c$ are sufficiently small, then $\chi_c \approx 0$ holds (i.e., $\chi_c$ is approximately zero). In other words, these expressions state that if the elasticity of substitution between any two differentiated goods ($\sigma$) is high, the iceberg transport cost of shipping the differentiated goods between countries ($\tau$) is high, the fraction of their consumption expenditure on the differentiated goods ($\alpha$) is small, and the tariff rate is small, then $\chi_c \approx 0$ holds. Under these assumptions, we can clearly see the effect of an increase in the tariff rate in each country. In this case, world consumption expenditure is as follows:

$$E + E^* = 2 + \frac{\rho \eta}{\gamma L}.$$

(18)

From (15) and (18), we then obtain the following world growth rate:
\[ g = \frac{2aL\gamma}{\eta\sigma} - \frac{\rho(\sigma - a)L}{\sigma}. \]  

(19)

Substituting (16) and (17) into the equilibrium share of firms in the home country given by equation (11) and considering \( \gamma_c \approx 0 \), we obtain:

\[ \gamma = \frac{\left(L + \frac{\rho \eta k}{\gamma}\right) - (1 + \tau_c)^{1-\sigma} \left[L + \frac{\rho \eta (1-k)}{\gamma}\right]}{\left[1 - (1 + \tau_c)^{1-\sigma}\right] \left(2L + \frac{\rho \eta}{\gamma}\right)}. \]  

(20)

From (20), we obtain the following quadratic equation in \( \gamma \):

\[ D_1 \gamma^2 + D_2 \gamma + D_3 = 0, \]  

(21)

where

\[ D_1 = 2L^2 \left[1 - (1 + \tau_c)^{1-\sigma}\right] > 0, \]  

(22)

\[ D_2 = (\rho \eta - L) \left[L - (1 + \tau_c)^{1-\sigma}\right], \]  

(23)

\[ D_3 = - \rho \eta \left[k - (1 + \tau_c)^{1-\sigma}(1-k)\right] < 0. \]  

(24)

As in Martin and Ottaviano (1999), the positive root of this equation,

\[ \gamma = - \frac{D_2 + \sqrt{D_2^2 - 4D_1D_3}}{2D_1}, \]  

(25)

is the valid solution.

V. Impact of Tariff Reductions

Next, we analyze the location effects of a simultaneous reduction in the common tariff rate in both countries. From equation (25), we obtain:

\[ \left. \frac{\partial \gamma}{\partial \tau_c} \right|_{\tau_c = 0} < 0. \]  

(26)
Equation (26) implies that a reduction in the common tariff rate of both countries induces the global relocation of firms to the home country. An intuitive explanation for this result is as follows. First, when common tariff rates are reduced, firms will pay more attention to the relative market size of each country when deciding where to locate. This is because even if tariff rates are reduced, transport costs remain constant, and thus the advantages of each country's relative market size become more pronounced due to the existence of firms' motivation to save on transport costs. Here, in our model, the initial condition $K > K^*$ implies $E > E^*$, because more capital income from the capital stock will be brought to the home country by firms. Therefore, in the case where $E > E^*$, a reduction in tariff rates leads to a further increase in the relative profits of firms located in the home country both due to the exploitation of increasing returns to scale in the differentiated goods sector in the home country and due to the avoidance of the burden of transport costs associated with exporting, and consequently foreign firms relocate to the home country. Thus, as shown in (26), a reduction in the common tariff rate of both countries induces the global relocation of firms to the home country. This mechanism is key to understanding the positive effect of a simultaneous reduction in the common tariff rate on the world growth rate, which will be examined below.

Next, we analyze the effect of a simultaneous reduction in the tariff rate of both countries on the world growth rate through the effect on the international relocation of firms. From (19) and taking into account the result of (26), we obtain:

$$\frac{\partial q}{\partial \tau_c} \bigg|_{\tau_c = 0} < 0.$$  (27)

Recall that in our model, the larger initial capital stock in the home country ($K > K^*$) leads to higher real expenditure on differentiated goods in the home country than in the foreign country ($E > E^*$). As a result, the number of firms producing in the home country ends up being larger than in the foreign country. Moreover, in our model with localized knowledge spillovers, all R&D activity occurs in the home country, where a larger number of firms are located. This is because in our model with localized knowledge spillovers, the cost of R&D in a location is negatively proportional to the number of firms already located there. Therefore, the world growth rate is determined by the R&D activity of the home country. For this reason, the world growth rate depends positively on the share of home country firms, as shown in equation (19). Here, when tariff rates are lowered, because transport costs remain constant, the advantages of each country's relative market size become more pronounced, both by avoiding the transport cost burden associated with exporting and by exploiting increasing returns to scale in the differentiated goods sector, the home country (with its higher capital stock) ends up with an even higher concentration of firms. Thus, as seen in equation (27), a simultaneous
reduction in the common tariff rate of both countries results in an increase in the world growth rate due to the reduction in R&D costs resulting from the even higher concentration of firms in the home country and the associated increase in innovation.

**VI. Welfare Analysis**

We now consider the impact of a reduction in the common tariff rate on the welfare of each country, as measured by the utility of the representative household. Our interest is to show the difference between the welfare effects of economic integration through a reduction in the common tariff rate in this study and the results of Martin and Ottaviano (1999), who found that economic integration through a reduction in transport costs improves the welfare gains of agglomerating and non-agglomerating countries.

The indirect utilities in the home country and the foreign country are as follows:

\[
U(0) = \frac{1}{\rho} \log \left( a^{a}(1-a)^{1-a} \left( 1 + \frac{\rho \eta k}{\gamma L} \right) \left( \frac{\sigma-1}{\beta \sigma} \right)^{a} N(0)^{\frac{a}{\sigma-1}} \left[ 1 - (1 + \tau_{e})^{1-\sigma \delta} \right] \gamma \right.
\]

\[+ (1 + \tau_{e})^{1-\sigma \delta} \left( \frac{\sigma-1}{\sigma-1} e^{\rho(\sigma-1)} \right), \quad (28)\]

\[
U^{*}(0) = \frac{1}{\rho} \log \left( a^{a}(1-a)^{1-a} \left( 1 + \frac{\rho \eta (1-k)}{\gamma L} \right) \left( \frac{\sigma-1}{\beta \sigma} \right)^{a} N(0)^{\frac{a}{\sigma-1}} \right.
\]

\[\left[ 1 - \left( 1 + \tau_{e} \right)^{1-\sigma \delta} \right] \gamma^{a} e^{\rho(\sigma-1)}, \quad (29)\]

First, we examine the welfare impact of a simultaneous multilateral tariff reduction on home welfare through the agglomeration of firms into the home country. Differentiating equation (28) with respect to \( \tau_{e} \) yields

\[
\frac{\partial U(0)}{\partial \tau_{e}} = -\left( \frac{\eta k}{\gamma L + \rho \eta k} \right) \frac{\partial \gamma}{\partial \tau_{e}} + \left( \frac{2 L a^{2}}{\rho \sigma (\sigma-1)} \right) \frac{\partial \gamma}{\partial \tau_{e}}
\]

\[+ \left( \frac{\alpha}{\rho (\sigma-1)} \right) \left[ \frac{1 - (1 + \tau_{e})^{1-\sigma \delta}}{1 - (1 + \tau_{e})^{1-\sigma \delta} \gamma + (1 + \tau_{e})^{1-\sigma \delta}} \right] \frac{\partial \gamma}{\partial \tau_{e}}
\]

\[-\left( \frac{\alpha}{\rho} \right) \left[ \frac{\delta (1 + \tau_{e})^{-\sigma} (1-\gamma)}{1 - (1 + \tau_{e})^{1-\sigma \delta} \gamma + (1 + \tau_{e})^{1-\sigma \delta}} \right] \frac{\partial \gamma}{\partial \tau_{e}} \quad (30)
\]
As in the results on welfare gains in Martin and Ottaviano (1999), the first term on the right-hand side of (30) is the negative income effect that an increase in $\gamma$ through a decrease in $\tau_c$ has on the wealth of the home country. This is because the concentration of firms in the home country further increases the number of new entrants into R&D in the home country due to local knowledge externalities, and the increased competition resulting from the increase in additional blueprints reduces the profits of existing firms. A fall in the value of firms means a fall in the value of stocks held by households, which reduces household income. Following Martin and Ottaviano (1999), we define this as the income effect. The second term represents the positive growth effect that an increase in $\gamma$ through a decrease in $\tau_c$ has on the world growth rate. This is because the concentration of firms in the home country increases the number of new firms through an increase in R&D, which increases the wealth of the home country additionally. In this paper we define this as the growth effect, following Martin and Ottaviano (1999). The third term represents the welfare improvement due to the reduction in transport costs for consumers in the home country when $\gamma$ is increased by a reduction in $\tau_c$. This is due to the increase in the number of firms in the home country, which has enabled households in the home country to reduce the amount of foreign imports, thereby saving unnecessary transport costs. This is referred to in this paper as the transport cost effect. The fourth term is the positive effect of common tariff reductions, which results from the reduction of the market distortions due to the existence of tariffs. This is a new welfare effect not found in Martin and Ottaviano (1999) and is defined in this paper as the market distortion effect. Note that the market distortion effect depends on the number of firms in a country ($\gamma$). That is, the larger the number of firms located in the home country ($\gamma$), the smaller the positive market distortion effect in the home country. This can be explained as follows: the higher the number of firms located in a country ($\gamma$), the lower the country's dependence on imports, which reduces the market distortions caused by tariffs.

To summarize, in our model there is a negative welfare effect from the income effect and a positive welfare effect from the growth effect, the transport cost effect and the market distortion effect on the welfare gains of the home country. Therefore, the net welfare effect of a multilateral tariff cut on the home country depends on the relative strength of these countervailing effects. However, as shown in equation (30), for consumers in the home country, the net effect of these four effects is ambiguous in terms of welfare.

Similarly, differentiating equation (29) with respect to $\tau_c$ gives the following for the welfare impact on the foreign country:
\[
\frac{\partial U(0)}{\partial \tau_c} = -\left(\frac{\eta(1-k)}{\gamma^2L+\rho\eta\gamma k}\right) \frac{\partial \gamma}{\partial \tau_c} + \left(\frac{2L\alpha^2}{\rho^2\eta\sigma(\sigma-1)}\right) \frac{\partial \gamma}{\partial \tau_c} \\
-\left(\frac{a}{\rho(\sigma-1)}\right) \left(\frac{1 - (1+\tau_c)^{1-\sigma}\delta}{1 - (1 - (1+\tau_c)^{1-\sigma}\delta)}\right) \frac{\partial \gamma}{\partial \tau_c} \\
-\left(\frac{a}{\rho}\right) \left(\frac{\delta(1+\tau_c)^{-\sigma}(1-\gamma)}{1 - (1 - (1+\tau_c)^{1-\sigma}\delta)}\right). \quad (31)
\]

The first term on the right-hand side of (31) is the negative income effect that an increase in \(\gamma\) through a decrease in \(\tau_c\) has on the wealth of the foreign country. The second term represents the positive growth effect of an increase in \(\gamma\) through a decrease in \(\tau_c\). The third term represents the negative welfare effect due to the increase in the transport cost burden for consumers in the foreign country when \(\gamma\) is increased by a decrease in \(\tau_c\). The fourth term is the positive market distortion effect of tariff reductions per se, which reduces the market distortions associated with the existence of tariffs. Note that the positive market distortion effect associated with tariffs also occurs in non-agglomerated foreign countries and depends on the number of firms located in the home country \(\gamma\): the larger the number of firms located in the home country \(\gamma\), the larger the positive market distortion effect in the foreign country, which is the opposite of that the home country. This is because the larger the number of firms located in the home country \(\gamma\), the greater the dependence of the foreign country on the home country in terms of imports, and hence the greater the effect of reducing market distortions through lower tariff rates in the foreign country.

In summary, in our model there are negative welfare effects from the income effect and the transport cost effect, and positive welfare effects from the growth effect and the market distortion effect with respect to the welfare effect of a multilateral reduction in the common tariff rate in the foreign country. Therefore, the net welfare effect of a multilateral tariff reduction on the welfare of the foreign country depends on the relative strength of these countervailing effects. For consumers in the foreign country, however, the net welfare effect of these four effects is ambiguous.

Accordingly, equations (30) and (31) show that, because of these four opposing influences, regardless of countries, the welfare effect of a reduction in the common tariff rate is ambiguous. Recall from our earlier explanation that, for simplicity, we assume that \(\chi_c = a\tau_c(1+\tau_c)^{-\sigma}\delta \approx 0\). Intuitively, if \(\sigma\) and \(\tau\) are sufficiently large and \(a\) and \(\tau\) are sufficiently small, then \(\chi_c \approx 0\) (i.e. \(\chi_c\) is approximately zero). Under this assumption, it follows from equations (30) and (31) that the growth effect, the transport cost reduction effect and the distortion reduction effect become sufficiently small, while the negative income effect of an increase in the number of firms due to an increase in the world growth rate becomes relatively large, so that the welfare
gains of both home and foreign households can always be negative. On the other hand, the study by Martin and Ottaviano (1999), although it is a numerical calculation, in the base case, shows that the welfare gains of the home country due to economic integration through the reduction of transport costs are always positive and the economic welfare of the foreign country is also positive. Thus, although the effects of economic integration through a reduction in transport costs and the effects of economic integration through a reduction in tariffs are the same in terms of further agglomeration of firms in the agglomerating country and an increase in the global economic growth rate, they are opposite in terms of their effects on the welfare gains of agglomerating and non-agglomerating countries. It can be said that this phenomenon could not be explained by Martin and Ottaviano (1999) and was shown for the first time by considering the growth effect of economic integration through a reduction in tariff rates.

But why do the welfare gains results in this paper and in Martin and Ottaviano (1999) show the opposite, even though the same model analyzes the effects of economic integration? This is because, in the analysis of Martin and Ottaviano (1999), economic integration in terms of a fall in transport costs, so that the positive welfare effect of lower transport costs per se becomes larger than other negative welfare effects. On the other hand, the analysis in this paper defines economic integration in terms of lower common tariff rates, which means that there are no direct economic gains from lower transport costs. Indeed, for this reason, Martin and Ottaviano (1999) found that economic integration due to lower transport costs led to positive welfare gains for both enterprise-intensive and non-intensive regions. Conversely, in the welfare analysis in this paper, there is no welfare gain from lower transport costs per se as in Martin and Ottaviano (1999), which results in that the negative welfare effect due to the income effect outweighs other positive welfare effects and has a negative impact on the welfare gains of both agglomeration countries and agglomeration regions. This is the reason why this paper and the benchmark model produce different results in terms of welfare gains.

VII. Conclusion

This paper analyzed the effect of a simultaneous reduction in the common tariff rate of two countries on the world growth rate through the effect on the international relocation of firms. From this analysis, we found that under localized spillovers in innovative R&D, a simultaneous reduction in the common tariff rate of both countries will increase the world growth rate due to the reduction in R&D costs resulting from an even greater concentration of firms in the home country with a larger economy. Finally, we have shown in the welfare analysis that when all countries simultaneously reduce their tariff rates, although firms relocate from the non-agglomerating country to the agglomerating country and the welfare of both home
and foreign households falls, in contrast to the benchmark model. This suggests that the welfare effects of economic integration through a reduction in the common tariff rate derived from the welfare analysis may differ from the effects of economic integration through a reduction in transport costs, despite the same economic integration.

References


