Brand Agriculture and Economic Geography:  
A General Equilibrium Analysis

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Brand Agriculture and Economic Geography: 
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Abstract

This paper presents a general equilibrium model of NEG incorporating the brand agriculture which produces differentiated agricultural products. Focusing on the core-periphery space, we show that highly differentiated brand agriculture can be sustained in the periphery even when the accessibility to the core market is not particular good. This result supports the promotion of innovative products in rural area in order to avoid direct price competition in generic commodity market under unfavorable condition.

Keywords: brand agriculture, NEG, core-periphery

JEL Classification: O21, Q10, R13

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1 Introduction

Most existing models of economic development posit for the agricultural sector a role that consists of producing generic commodities or food to cities, while development is characterized by the growth of the "modern" industrial sector absorbing the excess labor from the rural sector. The agricultural sector has been paid little attention as the engine of economic growth, generally being attributed constant returns to scale technology without product differentiation, innovation, and knowledge externalities.

Agricultural sector has a specific characteristics of being bound to land. Therefore, its activities are geographically dispersed and cannot form a large dense concentration. This may be disadvantageous for innovation dynamics which can be stimulated by knowledge spillover within an agglomeration. The dispersed location also leads to disparity of competitive condition depending on the accessibility of principal markets. Other natural conditions such as topography, land fertility, and climate also greatly affect the productivity of agriculture. In reality, a significant proportion of the population resides in rural area, and thus improving their living condition is one of great concerns for policy makers. If farmers at disadvantageous locations were to continue producing only generic goods under perfect competition, intensifying pressure from global trade liberalization will leave them no room but for surviving with subsidies.

In the past the location of agriculture has been studied by using the bid-rent approach originated by von Thünen\(^1\). The von Thünen model is based on the neoclassical assumption of perfect competition and constant return to scale. Within such framework, high valued products tend to locate near the market

\(^1\)For detail, see Chapter 3 in Fujita and Thisse, 2002.
(city) while the remote periphery is occupied by low valued commodity which needs extensive use of the land.

Recently, Fujita (2006) challenged this view by proposing a model introducing product differentiation in the agricultural sector. He showed that appropriate location of differentiated agriculture depends on its degree of product differentiation. Namely, the less differentiated products such as fresh vegetables should be grown near the metropolis because they are close substitutes for generic products, but highly unique products can be produced in remote villages using strong monopolistic power as well as taking advantage of low land rent and wage. This result implies that differentiated products with certain monopolistic power can avoid direct competition in price and cost, leading to granting higher income to producers. Thus, they are suitable to farmers without good accessibility to large markets.

As an extension of Fujita (2006) that was studied within a restrictive partial equilibrium framework, this paper introduces differentiated agricultural products in the standard general equilibrium model of the New Economic Geography (NEG). Farmers in this sector produce differentiated agricultural products (denoted as brand agricultural products) involving economies of scale. In this context, we examine the location of brand agriculture in terms of the degree of product differentiation and transport costs using the potential function approach. This paper also aims at providing a theoretical basis for the policy discussion on the role of innovation and infrastructure in rural development.

In reality, rural development based on brand agriculture is not new. In the remote regions of Japan today, for instance, there exit hundreds of small villages where highly unique agricultural goods are produced. For example, when we
visited a small town called Kamikatsu located in deep mountain of Shikoku Island of Japan, we witnessed highly successful business run by the organization of town residents producing the ornaments made of local leaves and flowers used by sophisticated Japanese cuisine restaurants. They have established unique business model utilizing information technology and air cargo transportation for the on-demand delivery of seasonal objects requested by the restaurants. They now earn nearly ten times as high income as the past when they used to lived on ordinary forestry and tangerine farming. For another instance, Japan imported 359 tones of roses from Kenya in 2006, roughly corresponding to 8% in quantity and 20% in value of the total imports of that product. As shown by the numbers, Kenyan roses are of higher value. Such roses are grown in the high land of more than 1000 meter height on the equator. The place offers natural advantage for the production of high quality flowers with constant climate having long hours under day light during the whole year, large temperature gap between the day and the night, and lower risk of harmful insect. Despite the long distance, exports to Japan became possible thanks to the provision of cold storage house in Dubai airport which is used for the transit of the air cargo. These examples suggest that remote rural are can be connected to a large market by utilizing efficient transportation system and product differentiation taking advantage of the local natural condition.

In the next section, we present the basic structure of the model in general setting. In Section 3, in the context of a hub-and-spoke system of the core-periphery economy, we derive outcomes in the factor market and those in the product markets. Based on these results, Section 4 examines the location equilibrium without considering the mobility of workers among regions. In Section
5, we allow the migration in response to the real wage difference and analyze the properties of the long-run equilibrium. Some policy implications are drawn in the final section.2

2 Model

2.1 Utility and demand

The economy has three types of products, the generic agricultural product (A), the differentiated agricultural products dubbed as the "brand agricultural products" (B), and the manufactured products (M). Both B-products and M-products consist of a continuum of varieties. All consumers of the economy share the same utility function described as

\[ U = A^{\alpha_A} B^{\alpha_B} M^{\alpha_M} \quad \text{where} \quad \alpha_A + \alpha_B + \alpha_M = 1. \]  

(1)

where A is the consumption of A-product whereas B and M represent respectively the index of the consumption of B-products and that of M-products. When B-sector and M-sector respectively provide a continuum of differentiated varieties of size \( n^B \) and \( n^M \), the indexes B and M are given by

\[ B = \left[ \int_0^{n^B} x(i)^{\rho_B} di \right]^{1/\rho_B} \quad \text{and} \quad M = \left[ \int_0^{n^M} q(j)^{\rho_M} dj \right]^{1/\rho_M} \]

where \( x(i) \) and \( q(j) \) represent respectively the consumption of B-variety \( i \in [0, n^B] \) of that of M-variety \( j \in [0, n^M] \). The parameters \( \rho_B \) and \( \rho_M \) stand

Although the present paper uses a static framework, it is possible to extend the model to a dynamic framework in which new brand agrarian products are consecutively developed over time as in Fujita and Thisse (2003).
for substitutability of each variety over the differentiated products. When $\rho_B$ is close to 1, for example, differentiated $B$-products are nearly perfect substitutes for each other while as $\rho_B$ decreases towards 0, the desire to consume greater variety of $B$-products increases. If we set $\sigma_B \equiv 1/(1-\rho_B)$ and $\sigma_M \equiv 1/(1-\rho_M)$, then $\sigma_B$ represents the elasticity of substitution between any pair of varieties of $B$-products, and $\sigma_M$ that of $M$-products, taking values between 1 and $\infty$.

If $Y$ denotes the consumer income, $P^A$ the price of $A$-product, $p^B(i)$ the price of $i$-th variety of $B$-products, and $p^M(j)$ the price of $j$-th variety of $M$-products, the demand functions are

\[
A = \frac{\alpha_A Y}{P^A}, \quad (2)
\]

\[
x(i) = \alpha_B Y p^B(i)^{-\sigma_B} (P^B)^{\sigma_B-1}, \quad (3)
\]

\[
q(j) = \alpha_M Y p^M(j)^{-\sigma_M} (P^M)^{\sigma_M-1}, \quad (4)
\]

where $P^B$ and $P^M$ are respectively the price index of $B$-products and that of $M$-products given by

\[
P^B = \left[ \int_0^\infty p^B(i)^{-\sigma_B-1} di \right]^{-1/(\sigma_B-1)}, \quad (5)
\]

\[
P^M = \left[ \int_0^\infty p^M(j)^{-\sigma_M-1} dj \right]^{-1/(\sigma_M-1)}. \quad (6)
\]

Using (1) to (6), we obtain the indirect utility function:

\[
V = Y (P^A)^{-\alpha_A} (P^B)^{-\alpha_B} (P^M)^{-\alpha_M}. \quad (7)
\]
2.2 Location and transport costs

Let \( r = 1, 2, \ldots, N \) represent each region in the economy. We assume the "iceberg transport cost" regarding the inter-regional trade. Specifically, if a unit of any variety of \( B \)-product is shipped from a region \( r \) to another region \( s \), only a fraction \( 1/T_{rs}^{B} \) of the original unit actually arrives while the rest perishes away on its way. Likewise, we define the transport parameter for \( A \)-product and \( M \)-products respectively by \( T_{rs}^{A} \) and \( T_{rs}^{M} \), where \( T_{rs}^{A} > 1, T_{rs}^{B} > 1, T_{rs}^{M} > 1 \) for \( r \neq s \). Let \( P_{r}^{A} \), \( P_{r}^{B} \), and \( P_{r}^{M} \) be respectively the f.o.b. price of \( A \)-product, that of \( B \)-products, and that of \( M \)-products in region \( r \). Then, the transport technology implies that the delivered (c.i.f) prices \( P_{rs}^{A} \), \( P_{rs}^{B} \), and \( P_{rs}^{M} \) in region \( s \) are given by

\[
 P_{rs}^{A} = P_{r}^{A} T_{rs}^{A}, \\
 P_{rs}^{B} = P_{r}^{B} T_{rs}^{B}, \\
 P_{rs}^{M} = P_{r}^{M} T_{rs}^{M}.
\]

We assume no transportation cost within the same region, i.e. \( T_{rr}^{A} = T_{rr}^{B} = T_{rr}^{M} = 1 \).

Let \( n_{r}^{B} \) be the number of \( B \)-products produced in region \( r \) (which equals the number of \( B \)-firms in region \( r \)), and \( n_{r}^{M} \) the number of \( M \)-products produced in region \( r \) (the number of \( M \)-firms in region \( r \)). Then, (5) and (6) become

\[
 P_{r}^{B} = \left[ \sum_{s=1}^{N} (T_{sr}^{B})^{-(\sigma_{B}-1)} n_{s}^{B} (P_{s}^{B})^{-(\sigma_{B}-1)} \right]^{-1/(\sigma_{B}-1)} \tag{8}
\]

\[
 P_{r}^{M} = \left[ \sum_{s=1}^{N} (T_{sr}^{M})^{-(\sigma_{M}-1)} n_{s}^{M} (P_{s}^{M})^{-(\sigma_{M}-1)} \right]^{-1/(\sigma_{M}-1)} \tag{9}
\]
2.3 Production

2.3.1 Generic agriculture

The farmer of generic agriculture produces a unit of A-product using one unit of land and $c_A$ unit of labor. Let $w_r$ and $R_r$ be the wage and the land rent in region $r$, then the profit per unit of land earned by A-product farmer in region $r$ is $\pi_r^A = a_rP_r^A - c_Aw_r - R_r$. Since the A-product market is in perfect competition, the equilibrium profit becomes zero. Thus, setting $\pi_r^A = 0$, we obtain the A-sector’s bid-rent in region $r$ which represents the maximum rent that an A-sector farmer can pay in region $r$:

$$R_r^A = a_rP_r^A - c_Aw_r$$  \hspace{1cm} (10)

2.3.2 Brand agriculture

The technology in B-sector is such that one unit of output requires the composite of one unit of land and $c_B$ units of labor. We also assume that fixed $f_B$ units of the same composite are required. Due to the fixed input, economies of scale arise at the level of variety. When a farm produces $x_r$ units of a B-product in region $r$, the profit is

$$\pi_r^B = p_r^B x_r - (c_Bw_r + R_r) x_r - (c_Bw_r + R_r) f_B$$  \hspace{1cm} (11)

Using (3), when the f.o.b. price of a B-product produced in region $r$ is $p_r^B$, the demand for the product in region $s$ is given by

$$x_{rs} = \alpha_B Y_s \left[ p_r^B T_{rs} \right]^{-\sigma_B} \left( p_s^B \right)^{\sigma_B - 1} T_{rs}^B.$$  \hspace{1cm} (12)
Hence, the total demand of the product from $N$ regions is

$$x_r = \sum_{s=1}^{N} x_{rs} = \sum_{s=1}^{N} \alpha_B Y_s \left[ p_r B^{\sigma_B} T_{rs}^{B} \right]^{-\sigma_B} (P_s^B)^{\sigma_B} - 1 T_{rs}^B. \tag{13}$$

Assuming that each $B$-sector farm takes the price index (8) as given, the f.o.b. price $p_r^B$ that maximizes profit (11) is given by

$$p_r^B = \frac{c_B w_r + R_r}{\rho_B}. \tag{14}$$

Since the marginal cost is $c_B w_r + R_r$, (14) means that each farm uses a mark-up equal to $1/\rho_B$. Notice that smaller $\rho_B$ (i.e. smaller $\sigma_B$) means a higher degree of product differentiation leading to a higher mark up. Substituting (14) into (8) yields

$$P_r^B = \frac{1}{\rho_B} \left[ \sum_{s=1}^{N} (T_{sr}^B)^{-\sigma_B} n_s^B (c_B w_s + R_s)^{-\sigma_B} \right]^{-1/\sigma_B}. \tag{15}$$

Substituting (14) and (15) into (13) yields the total sales of a variety of $B$-products produced in region $r$ under the equilibrium price (14)

$$\tilde{x}_r = \frac{(\rho_B)^{\sigma_B}}{c_B w_r + R_r} \sum_{s=1}^{N} \frac{\alpha_B Y_s (P_s^B)^{\sigma_S} - 1}{(c_B w_r + R_r) T_{rs}^B} \tag{16}.$$

In this expression, the denominator in the first term represents the fixed cost advantage of region $r$, which is stronger as the cost of labor and land is smaller. In the second term, $\alpha_B Y_s$ in the numerator is the expenditure for $B$-products in region $s$, whereas $(P_s^B)^{\sigma_B} - 1$ represents the inverse measure of the severeness of competition of $B$-products in the market $s$ because a higher price index $P_s^B$ means that it is easier to sell $B$-products in that market. Thus, the numerator
as a whole shows the potential market size of B-products in region \( s \). This is divided by \([(c_{Bw} + R_r)T_{rs}]^{\sigma_B - 1}\) in which \((c_{Bw} + R_r)T_{rs}\) represents the marginal cost in supplying a unit of a B-product from region \( r \) to \( s \). In sum, the second term of (16) gives the sum of the effective size of the demand in each market for a B-variety produced in region \( r \).

As a special case, suppose that \( \sigma_B \) is sufficiently close to one. Then, (16) can be approximated as follows:

\[
\tilde{x}_r = \frac{(\rho_B)\sigma_B}{c_{Bw} + R_r} \alpha_B \sum_{s=1}^{N} Y_s. \tag{17}
\]

Thus, when the products are highly differentiated, the effect of transportation cost vanishes and the effective size of the demand depends only on the fixed cost advantage. This result suggests the viability of brand agriculture in the remote periphery provided that these products are sufficiently differentiated.

Since (11) and (14) imply \( \pi^B_r = (c_{Bw} + R_r) \left( \frac{1}{\sigma_B - 1} x_r - f_B \right) \), by setting \( \pi^B_r = 0 \) we obtain the equilibrium output of each active B-product farm as

\[
x^* = (\sigma_B - 1)f_B. \tag{18}
\]

The associated equilibrium labor input is

\[
l^{B'}_r = c_{Bw} f_B. \tag{19}
\]

and land input is

\[
g^{B'}_r = \sigma_B f_B. \tag{20}
\]
Notice that since these results do not depend on location, the index \( r \) can be dropped. Setting \( \tilde{x}_r = x^* \) and solving the equation for \( R_r \) we obtain the bid-rent function of the B-product farm in region \( r \) as follows:

\[
R^B_r = k_B \left[ \sum_{s=1}^{N} Y_s \left( T^B_{rs} \right)^{-\left(\sigma_B - 1\right)} \left( F^B_s \right)^{\sigma_B - 1} \right]^{1/\sigma_B} - c_B w_r, \quad (21)
\]

where \( k_B \equiv \rho_B \left[ \frac{\alpha_B}{\left(\sigma_B - 1\right) \beta_B} \right]^{1/\sigma_B} \) is a positive constant. This bid-rent is the maximum rent that a B-sector farmer can pay under zero-profit. If the prevailing market land rent is greater than the bid-rent, the B-sector production cannot be sustained there because farmers’ profit turns negative. On the other hand, if the bid-rent is greater than the market rent, it implies that the farmers earn positive profit because \( \tilde{x}_r > x^* \). This will, in turn, induce more B-sector farmers to locate there and the competition eventually drives the profit to zero. Hence we have

\[
\eta^B_r > 0 \Rightarrow R^B_r = R_r \quad \text{and} \quad \eta^B_r = 0 \Rightarrow R^B_r \leq R_r.
\]

### 2.3.3 Manufacturing

M-products are produced using labor only. M-sector firms require marginal input of \( c_M \) units of labor in addition to \( c_M f_M \) units of fixed labor. Thus, the profit of a firm in region \( r \) is given by

\[
\pi^M_r = p^M_r q_r - w_r c_M q_r - w_r c_M f_M \quad (22)
\]

where \( q_r \) represents the sales of the firm’s product given by (4). Using (4), when the f.o.b. price of a M-product produced in region \( r \) is \( p^M_r \), the demand for the
product in region $s$ is given by

$$q_{rs} = \alpha_M Y_s [\rho^M r_{rs}^{M}]^{-\sigma_M} (P^M_s)^{\sigma_M - 1} T^M_{rs}, \quad (23)$$

Hence, the total demand of the product from $N$ regions is

$$\tilde{q}_r = (\rho_M)^{\sigma_M} \sum_{s=1}^{N} \alpha_M Y_s \left[ P^M_s \right]^{\sigma_M - 1} \frac{w_r c_M T^M_{rs}}{w_r c_M T^M_{rs}} - (\sigma_M - 1) \quad (24)$$

Assuming that each firm takes the price index $P^M_r$ as given, the f.o.b. price that maximizes the profit (22) is given by

$$p^M_r = \frac{w_r c_M}{\rho_M} \quad (25)$$

Substituting equation (25) into (9) yields

$$P^M_r = \frac{c_M}{\rho_M} \left[ \sum_{s=1}^{N} \left( T^M_{sr} \right)^{-(\sigma_M - 1)} \frac{M_s}{w_r c_M T^M_{rs}} \right]^{1/(\sigma_M - 1)} \quad (26)$$

As for the case of $B$-products demand, (24) takes into account effective size of demand of each market.

Since (22) and (25) imply $\pi^M_r = \left( \frac{q^M_r}{\sigma_M - 1} - f_M \right) w_r c_M$, by setting $\pi^M_r = 0$ we obtain zero-profit equilibrium output of each active M-firm in region $r$ as

$$q^* = (\sigma_M - 1) f_M \quad (27)$$

and the associated labor input $l^{M*} = c_M \sigma_M f_M$. 

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2.4 The equilibrium of factor markets when workers are immobile

For the moment, let us consider the situation where the population \( L_r \) in region \( r \) is fixed. This may represent the case where each region represents a small country. Or, it may represents a short-run equilibrium. Later, we will relax this assumption and allow migration in response to the real wage difference.

First, consider the land market. Let \( G_r \) be the size of the land in region \( r \). Land is used by both \( A \)-sector and \( B \)-sector and \( G^A_r \) denotes the land utilized by the former and \( G^B_r \) the latter. Since \( a_r \) units of \( A \)-product can be produced on one unit of land, if \( Q^A_r \) is the total output of \( A \)-product in region \( r \), the land used by \( A \)-sector in region \( r \) is

\[
G^A_r = \frac{Q^A_r}{a_r} \tag{28}
\]

Given the land input (20) of a \( B \)-product farmer producing the equilibrium output, the land used by \( n^B_r \) varieties of \( B \)-product farmers in region \( r \) is given by

\[
G^B_r = n^B_r \sigma_B f_B \tag{29}
\]

When \( R_r > 0 \), the land in region \( r \) is fully occupied by the two types of agriculture, implying that

\[
R_r > 0 \implies G^A_r + G^B_r = G_r \tag{30}
\]

Assuming perfectly competitive land market, the equilibrium land rent \( R_r \) in
region \( r \) equals the highest bid rent:

\[
R_r = \max \{ R_A^r, R_B^r \}.
\]  

(31)

where \( R_A^r \) and \( R_B^r \) are respectively given by (10) and (21).

Regarding the labor market, let the labor demand in region \( r \) for each sector be \( L_A^r, L_B^r, L_M^r \) respectively. We can readily derive

\[
L_A^r = \frac{c_A Q_A^r}{a_r} \quad \text{(32)}
\]

\[
L_B^r = n_r^B l_B^* = n_r^B c_B \sigma_B f_B \quad \text{(33)}
\]

\[
L_M^r = n_r^M l_M^* = n_r^M c_M \sigma_M f_M \quad \text{(34)}
\]

Since it holds in the labor market equilibrium that

\[
L_A^r + L_B^r + L_M^r = L_r, \quad \text{(35)}
\]

substitution of (32), (33) and (34) into (35) yields

\[
\frac{c_A Q_A^r}{a_r} + n_r^B c_B \sigma_B f_B + n_r^M c_M \sigma_M f_M = L_r. \quad \text{(36)}
\]

The total factor income in region \( r \) is

\[
Y_r = L_r w_r + G_r R_r \quad \text{(37)}
\]

Using (7), the real wage associated with the nominal wage \( w_r \) is given by

\[
\omega_r = w_r (P_A^r)^{-\alpha_A} (P_B^r)^{-\alpha_B} (P_M^r)^{-\alpha_M} \quad \text{(38)}
\]
When the population in each region is fixed, \( \omega_r \) may differ across regions. When labor is freely mobile among regions, \( \omega_r \) should be equalized for all \( r \) where \( L_r > 0 \).

3 The hub-and-spoke core-periphery economy

3.1 Specification of the spatial structure

Consider the core-periphery economic space with "hub-and-spoke" transportation system depicted by Figure 1. The core denoted as region 0 is a transportation hub that is directly connected with each region in the periphery consisting of \( m \) regions. For simplicity, we focus on the case of a symmetric geographic configuration. Region 0 is endowed with \( G_0 \) units of land and \( L_0 \) units of workers. Let region \( r = 1, \ldots, m \) represent each region in the periphery and we assume that all regions are endowed with the same \( G_1 \) units of land and \( L_1 \) units of workers.

Transport cost between region 0 and region \( r \) is symmetric in both directions and the same transport costs apply for all \( r \): \( T_{0r}^A = T_{r0}^A \equiv T_A; T_{0r}^B = T_{r0}^B \equiv T_B; T_{0r}^M = T_{r0}^M \equiv T_M \). We also assume that there is no direct transport connection within the periphery between region \( r \) and another region, say region \( s \neq r \), requiring that the trade between \( r \) and \( s \) always passes through region 0. Hence, the transport cost between region \( r \) and \( s \) is given by: \( T_{rs}^A = T_{sr}^A = (T_A)^2; T_{rs}^B = T_{sr}^B = (T_B)^2; T_{rs}^M = T_{sr}^M = (T_M)^2 \).

Suppose that all \( M \)-sector firms are located in region 0 and \( B \)-products are produced only in the periphery. In this configuration, \( M \)-products are exported from the core to each region in the periphery, whereas \( B \)-products are sold not only from each region in the periphery to the core but also among all regions in...
the periphery through region 0.

We assume that $A$-product is produced in all regions and each region is in self-sufficiency of $A$-product. Since $A$-product is a homogeneous good that consumers always buy from the cheapest source, this assumption implies that $T_A$ is so high that once brought to the other region the delivered price is always higher than the price of the local production. This condition is given by

$$\frac{1}{T_A} < \frac{P_0^A}{P_1^A} < T_A.$$  \tag{39}
We are now ready to specify the results obtained in the previous section in the context of the this geographic configuration. By condition (31), any attempt to produce \( B \)-products in region 0 should fail because no \( B \)-product farmer can bid out the prevailing market rent paid by \( A \)-product farmers. On the other hand, since both \( A \)-product and \( B \)-products are produced in the periphery, the two sectors must be able to pay the same land rent in zero-profit. To summarize,

\[
Q_A^0 > 0, \quad n_0^B = 0 \Rightarrow R_0 = R_0^A \geq R_0^B
\]
\[
Q_A^1 > 0, \quad n_1^B > 0 \Rightarrow R_1 = R_1^A = R_1^B
\]

We set \( w_0 = 1 \) for normalization. Then, the land rent in region 0 given by (10) can be written as

\[
R_0 = a_0 P_0^A - c_A
\]

In each region of the periphery, using (40) we can express the land rent

\[
R_1 = a_1 P_1^A - c_A w_1 = R_1^B
\]

Price indices and regional income are specified as follows. Using (15) and (26), price indices of differentiated \( B \)-products and \( M \)-products in each region are derived as:

\[
P_0^B = T_B \left( mn_1^B \right)^{-1/(\sigma_{B1} - 1)} \frac{c_B w_1 + R_1}{\rho_B}
\]
\[
P_1^B = \left\{ (m - 1) T_B^{-2(\sigma_{B1} - 1)} + 1 \right\} n_1^B \left[ \frac{1}{\sigma_{B1} - 1} \right] \frac{c_B w_1 + R_1}{\rho_B}
\]
\[
P_0^M = \left( n_0^M \right)^{-1/(\sigma_{M1} - 1)} \frac{c_M}{\rho_B}
\]
\[
P_1^M = T_M \left( n_0^M \right)^{-1/(\sigma_{M1} - 1)} \frac{c_M}{\rho_B}
\]
Income in region 0 and each region in the periphery given by (37) are specified as:

\[ Y_0 = L_0 + G_0(a_0 P_0^A - c_A) \]  
\[ Y_1 = L_1 w_1 + G_1 (a_1 P_1^A - c_A w_1) \]

3.2 Market outcomes

In the context of the hub-and-spoke spatial system, we now examine the market clearing conditions of productive factors (labor and land) and products assuming that workers are immobile among regions.

3.2.1 Factor markets

In region 0, workers are employed either in \( A \)-sector or in \( M \)-sector. Using (36), the labor market clearing condition requires

\[ \left( \frac{c_A}{a_0} \right) Q_0^A + n_0^M c_M \sigma_M f_M = L_0 \]  

In each region in the periphery, workers are employed either in \( A \)-sector or in \( B \)-sector. Then, the labor market clearing condition is met when

\[ \left( \frac{c_A}{a_1} \right) Q_1^A + n_1^B c_B \sigma_B f_B = L_1 \]

Assuming that the land in region 0 is fully occupied by \( A \)-sector, equilibrium output of \( A \)-product in region 0 is given by
\[ Q_0^{A^*} = a_0 G_0. \] (51)

Substituting (51) into (49), we obtain the equilibrium size of \( M \)-product variety:

\[ n_0^M = \frac{L_0 - c_A G_0}{c_M \sigma_M f_M}. \] (52)

Notice that for \( n_0^M \) to be positive, it must hold that

\[ L_0 > c_A G_0. \] (53)

We assume this condition holds throughout the rest of our analysis.

The land in each region in the periphery accommodates both the generic agriculture and the brand agriculture. Thus, using (28) - (30) the land market equilibrium is given by

\[ \frac{Q_1^A}{a_1} + n_1^B \sigma_B f_B = G_1 \] (54)

Substitution of (54) into (50) yields the equilibrium size of \( B \)-product variety:

\[ n_1^B = \frac{L_1 - c_A G_1}{(c_B - c_A) \sigma_B f_B}. \] (55)

Using (54) and (55), we obtain the equilibrium output of \( A \)-product in each region in the periphery:

\[ Q_1^{A^*} = \frac{a_1 (c_B G_1 - L_1)}{c_B - c_A} \] (56)
In order to be $Q_1^{A^*} > 0$ and $n_1^{B^*} > 0$, it must hold either

$$c_B > L_1/G_1 > c_A$$

(57)

or

$$c_B < L_1/G_1 < c_A,$$

implying that the labor intensities of the two types of agricultures are sufficiently different. Provided that the B-sector is more labor intensive than A-sector, we assume that condition (57) holds in the rest of the paper.

### 3.2.2 Product markets

Assuming the self-sufficiency of A-sector in each region, using (2), (47), (48), (51) and (56), the market clearing of A-product in each region means

$$a_0G_0 = \frac{\alpha_A (L_0 - c_A G_0)}{P_0^A} + a_0 \alpha_A G_0.$$  

$$\frac{a_1 (c_B G_1 - L_1)}{c_B - c_A} = \frac{\alpha_A w_1 (L_1 - c_A G_1)}{P_1^A} + a_1 \alpha_A G_1.$$  

Solving them for $P_0^A$ and $P_1^A$, we obtain

$$P_0^{A^*} = \frac{\alpha_A}{1 - \alpha_A} \frac{L_0/G_0 - c_A}{a_0}$$

(58)

$$P_1^A = \frac{\alpha_A}{a_1 w_1 - \alpha_A} \frac{L_1/G_1 - c_A}{a_1}$$

(59)

Next, we examine the inter-regional trade of M-products. Recall that all M-products are produced in region 0. Using (24), (26) and (27), the market clearing of a M-product is given by
\[ (\sigma_M - 1) f_M = \frac{\alpha_M (Y_0 + mY_1) \rho_M}{n_0^{M^*}} c_M \]  

Substituting (47) and (48) into (60), we obtain

\[ \frac{c_M \sigma_M f_M}{\alpha_M} n_0^{M^*} = L_0 + G_0(a_0P_A^0 - c_A) + m \left\{ L_1 w_1 + G_1 \left( a_1P_A^1 - c_Aw_1 \right) \right\} \]  

Substituting (52), (58) and (59) into (61), then solving the equation for \( w_1 \), we obtain the equilibrium wage of each region in the periphery:

\[ w_1^* = \frac{\alpha_B}{\alpha_M} \frac{(c_B - c_A) G_1 - \frac{L_1-c_AG_1}{\alpha_M + \alpha_B}}{c_B G_1 - L_1} \frac{L_0 - c_A G_0}{m(L_1 - c_A G_1)} \]  

Notice that for \( w_1^* > 0 \) it requires that \( (c_B - c_A) G_1 - \frac{L_1-c_AG_1}{\alpha_M + \alpha_B} > 0 \), or

\[ L_1 < \{ (\alpha_B + \alpha_M) (c_B - c_A) + c_A \} G_1, \]  

implying that labor size in each region in the periphery is not too large. This condition is assumed to hold in the rest of the paper. Substituting (62) into (59), the associated \( P_A^1 \) is given by

\[ P_A^1 = \frac{\alpha_A \alpha_B}{(1 - \alpha_A) \alpha_M} \frac{c_B - c_A}{a_1} \frac{L_0 - c_A G_0}{m(c_B G_1 - L_1)}. \]  

Then, (58) and (64) imply

\[ \frac{P_0^A}{P_A^1} = \frac{\alpha_M a_1}{\alpha_B a_0} \frac{m(c_B G_1 - L_1)}{(c_B - c_A) G_0}. \]  

Substituting (58), (62) and (64) into (41) and (42), equilibrium land rent in
each region is given by:

\[ R^*_0 = \frac{1}{1 - \alpha_A} \left( \alpha_A \frac{L_0}{G_0} - c_A \right) \]  \hspace{1cm} (66)

\[ R^*_2 = \frac{1}{1 - \alpha_A} \left\{ \alpha_A + \left( \frac{1 - \alpha_A}{L_1/G_1 - c_A} - \frac{1}{c_B - c_A} \right) c_A \right\} \]  \hspace{1cm} (67)

Finally, substituting (62) and (64) into (47) and (48), the income of each region is

\[ Y_0 = \frac{L_0 - c_A G_0}{1 - \alpha_A} \quad \text{and} \quad Y_1 = \frac{1}{m} \frac{\alpha_B L_0 - c_A G_0}{1 - \alpha_A}, \]  \hspace{1cm} (68)

which yield that

\[ \frac{Y_0}{Y_0 + mY_1} = \frac{\alpha_M}{\alpha_M + \alpha_B} \quad \text{and} \quad \frac{mY_1}{Y_0 + mY_1} = \frac{\alpha_B}{\alpha_M + \alpha_B}. \]  \hspace{1cm} (69)

4 Location equilibrium when workers are immobile

4.1 A-sector

Recall that we have assumed that A-product is in self-sufficient in all regions. This assumption relies on the condition given by (39). Substituting (65) into (39), this assumption is met when

\[ \frac{1}{T_A} < \frac{\alpha_M a_1 m (c_B G_1 - L_1)}{\alpha_B a_0 (c_B - c_A) G_0} < T_A. \]  \hspace{1cm} (70)
implying that transport cost for $A$-product is sufficiently high. In the rest of the paper, this condition is assumed to hold.

4.2 $B$-sector

So far, we have assumed a priori that all $B$-production is located in region 1. In this section, we examine the condition under which $B$-production is indeed never viable in region 1. To do so, we use the potential function approach proposed by Fujita, Krugman, and Venables (1999).

Suppose that a farmer starts producing $B$-product in region 0. Using (16), the effective size of demand $\tilde{x}_0$ is given by

$$\tilde{x}_0 = \frac{(\rho_B)^{\sigma_B}}{c_B + R_0} \left[ \frac{\alpha_B Y_0 (P_0^B)^{\sigma_B - 1}}{(c_B + R_0)^{\sigma_B - 1}} + \frac{\alpha_B m Y_1 (P_1^B)^{\sigma_B - 1}}{[c_B + R_0] T_B^{\sigma_B - 1}} \right].$$

(71)

Taking the ratio of $\tilde{x}_0$ over the zero-profit output $x^*$ given by (18), we have

$$\Omega_0^B \equiv \frac{\tilde{x}_0}{x^*} = \frac{\tilde{x}_0}{(\sigma_B - 1)f_B}$$

(72)

which we call the potential function of $B$-product in region 1. It is obvious by definition that

$$\pi_0^B \ll 0 \quad \text{as} \quad \Omega_0^B \ll 1$$

(73)

Hence, when $\Omega_0^B$ is greater than 1 (resp. less than 1), the brand agriculture is profitable (resp. not profitable) in region 1. Substituting (71) into (72) and
using (43) and (44), we obtain (see Appendix 2 for the derivation)

$$\Omega^B_0 = \left( \frac{c_B w_1 + R_1}{c_B + R_0} \right)^{\sigma_B} \left[ \frac{Y_0 + \frac{m}{(T_B^{m \sigma_B n - 1})} m Y_1}{Y_0 + m Y_1} \right] (T_B)^{\sigma_B - 1}$$

(74)

Hereafter, we assume that $m$ is so large that the term $\frac{m}{(T_B^{m \sigma_B n - 1})}$ in the numerator in brackets degenerates to one, and hence the term in brackets can be dropped. Then, further by substituting (62), (66) in (74) we obtain:

$$\Omega^B_0 = \left[ \frac{\alpha_M m (L_1 - c_A G_1)}{\alpha_B L_0 - c_A G_0} \right] \left[ 1 + \frac{1 - (\alpha_M + \alpha_B) L_0 / G_0 - c_A}{\alpha_M + \alpha_B c_B - c_A} \right]^{\sigma_B} (T_B)^{\sigma_B - 1}$$

(75)

Recall that $\alpha_A \equiv 1 - \alpha_M - \alpha_B$. Based on (73) we can examine the condition for $\Omega^B_1 \leq 1$ for the non-existence of $B$-sector in region 0. Using (75), this condition is specified as

$$\frac{\alpha_M m (L_1 - c_A G_1)}{\alpha_B L_0 - c_A G_0} \left[ 1 + \frac{1 - (\alpha_M + \alpha_B) L_0 / G_0 - c_A}{\alpha_M + \alpha_B c_B - c_A} \right] \geq (T_B)^{\sigma_B - 1}$$

(76)

where $L_1 / G_1 - c_A > 0$ by (57) and $L_0 / G_0 - c_A > 0$ by (53). This condition can be satisfied, for example, when $m$ is sufficiently large.

4.3 $M$-sector

Next, let us turn to the location equilibrium of $M$-sector. We apply the potential function approach again to examine the condition under which the production of $M$-product is not viable in the periphery as we stipulate for this geographic configuration.

Suppose that a firm starts producing $M$-product in the periphery. We define
the potential function as

$$
\Omega_M \equiv \frac{\tilde{q}_i}{q^2} = \frac{\tilde{q}_i}{(\sigma_M - 1)f_M}.
$$

(77)

Then the location equilibrium condition for M-sector can be stated as

$$
\pi_1^M \leq 0 \quad \text{as} \quad \Omega_1^M \leq 1
$$

(78)

Hence, when $\Omega_M$ is greater than 1 (resp. less than 1), the manufacturing is profitable (resp. not profitable) in the periphery. Using (24), the effective size of demand of a M-product produced in the periphery is given by

$$
\tilde{q}_i = \frac{\left(\rho_M\right)^{\sigma_M}}{w_0c_M} \left[ \frac{\alpha_M Y_0 \left(P_0^M\right)^{\sigma_M - 1}}{(w_1c_1T_M)^{\sigma_M - 1}} + \frac{\alpha_M Y_1 \left(P_1^M\right)^{\sigma_M - 1}}{(w_1c_1)^{\sigma_M - 1}} \right]
$$

$$
+ \frac{(m - 1)\alpha_M Y_1 \left(P_0^M\right)^{\sigma_M - 1}}{(w_1c_1 \left(T_M\right)^2)^{\sigma_M - 1}}
$$

(79)

Substituting (45), (46), (62), (69) and (79) into (77), we obtain (see Appendix 3 for the derivation):

$$
\Omega_1^M = \left[ \frac{\alpha_M}{\alpha_B} \frac{m \left(L_1 - c_AG_1\right)}{L_0 - c_AG_0} \frac{c_BG_1 - L_1}{(c_B - c_A)G_1 - \frac{L_1 - c_AG_1}{\sigma_M + \alpha_B}} \right]^{-\sigma_M}
$$

$$
\times \frac{\alpha_M + \alpha_B \left(T_M\right)^{2(\sigma_M - 1) + (m - 1)}m}{\alpha_M + \alpha_B m} \left(T_M\right)^{-(\sigma_M - 1)}
$$

(80)

Assuming that $m$ is a very large number, the term $\left\{(T_M)^{2(\sigma_M - 1) + (m - 1)}\right\} / m$ in the second term degenerates to one, hence the second term can be dropped.

With this assumption, we obtain the location equilibrium condition given by
Given (53), (57) and (63), the left hand is positive. It turns out that the left hand side of (81) is the inverse of the equilibrium wage in the periphery given by (62). Then, if \( w^*_1 > 1 \), the location equilibrium of \( M \)-sector always hold since \( T_M > 1 \) by definition. If \( w^*_2 < 1 \), this condition more likely holds with high \( T_M \) because the move to the periphery should cost the firm a loss of demand in the core market.

### 4.4 Location equilibrium

We are now ready to examine location equilibrium conditions of both \( B \)-sector and \( M \)-sector together. focusing on the values of \( \alpha_M + \alpha_B \) and \( \alpha_M / \alpha_B \), let the left hand side of (76) and that of (81) be defined respectively as follows:

\[
\varphi_B \left( \alpha_M + \alpha_B, \frac{\alpha_M}{\alpha_B} \right) \equiv \frac{\alpha_M}{\alpha_B} \frac{m (L_1 - c_A G_1)}{L_0 - c_A G_0} \left\{ 1 + \frac{1 - (\alpha_M + \alpha_B)}{\alpha_M + \alpha_B} \frac{L_0 / G_0 - c_A}{c_B - c_A} \right\}
\]

(82)

\[
\varphi_M \left( \alpha_M + \alpha_B, \frac{\alpha_M}{\alpha_B} \right) \equiv \frac{\alpha_M}{\alpha_B} \frac{m (L_1 - c_A G_1)}{L_0 - c_A G_0} \frac{c_B - L_1 / G_1}{(c_B - c_A) - \frac{L_1 / G_1 - c_A}{\alpha_M + \alpha_B}}
\]

(83)

Given a fixed value of \( \alpha_M / \alpha_B \), Figure 2 depicts \( \varphi_B \) and \( \varphi_M \) respectively as a function of \( \alpha_M + \alpha_B \). The two curves intersect at \( \alpha_M + \alpha_B = 1 \). It is vious
by the figure that if it holds that

$$
(T_B)^{-\alpha_B} < \frac{\alpha_M}{\alpha_B} \frac{m(L_1 - c_A G_1)}{L_0 - c_A G_0} < (T_M)^{-\alpha_M}
$$

then, there exits a range of parameters that satisfies both (76) and (81).

This result is summarized by the following proposition.

**Proposition 1** Suppose workers are immobile among regions. The hub-and-spoke system of the core-periphery spatial structure is in equilibrium when (76)
and (81) are satisfied. When condition (84) holds, there exists a range of parameters that satisfy both (76) and (81).

Proposition 1 confirms above discussion based on (17) that the brand agriculture is viable in the periphery even when its transport cost is high provided that these products are sufficiently differentiated. It also suggests that the core-periphery structure is more likely to be in equilibrium with higher transport cost of manufactured goods because, despite of the fixed cost advantage, firms find it not attractive to locate in the periphery for the loss of demand in the core market. Notice that the local market in the periphery is assumed to be fragmented due to the assumption of the hub-and-spoke structure.

5 Location equilibrium with mobile workers

So far, we have analyzed the market outcome assuming a fixed population distribution, ignoring inter-regional migration in response to the real wage difference. In this section, we relax this assumption and examine the location equilibrium with mobile workers, which may represent the case of long-run equilibrium where the real wage is equalized in all regions. Yet, keeping the assumption of symmetric regions in the periphery, we always assume $L_r = L_1$ for all $r$.

Let $L$ be the total number of workers in the economy. Then, we have

$$L_0 + mL_1 \equiv L.$$  \hspace{1cm} (85)

We assume that a worker moves toward the region that offers higher real wage. Specifically, we define an ad-hoc population dynamics:
\[ L_1 = L_1 (\omega_1 - \omega_0) L_0 \]  

(86)

Using (38), the real wage in each region is given by

\[ \omega_0 = \frac{1}{\left( P_A^{*} \right)^{\alpha_A} \left( P_B^{*} \right)^{\alpha_B} \left( P_M^{*} \right)^{\alpha_M}}. \]  

(87)

\[ \omega_1 = \frac{w_1^*}{\left( P_A^{*} \right)^{\alpha_A} \left( P_B^{*} \right)^{\alpha_B} \left( P_M^{*} \right)^{\alpha_M}}. \]  

(88)

By taking the ratio of real wages, we obtain

\[ \frac{\omega_1}{\omega_0} = w_1^* \left( \frac{P_A^{*}}{P_A^{*}} \right)^{\alpha_A} T_B^{\alpha_B} T_M^{-\alpha_M}. \]  

(89)

Substituting (65) and (62) into (89), real wage ratio is given by

\[ \frac{\omega_1}{\omega_0} = \frac{1}{\left( L_1 \right) \left( L_0 \right)} \left( \frac{\alpha_B}{\alpha_M} \frac{c_B - c_A}{m (c_B G_1 - L_1)} \right)^{\alpha_B + \alpha_M} \left( L - mL_1 - c_A G_0 \right) \times \left( \frac{1}{L_1 / G_1 - c_A} - \frac{1}{(\alpha_B + \alpha_M) (c_B - c_A)} \right) \left( \frac{a_1}{a_0 G_0} \right)^{1-\alpha_B - \alpha_M} T_B^{\alpha_B} T_M^{-\alpha_M}. \]  

(90)

Figure 3 depicts (90) taking \( L_1 \) on the horizontal axis. By the population dynamics given by (86), migration leads the economy to the equilibrium point \( E \) where \( \omega_0 = \omega_1 \). However, by condition given by (84), it should be satisfied that \( \frac{\alpha_B}{\alpha_M} \frac{L_1 - c_A G_1}{L_0 - c_A G_0} \geq 1 \), which yields

\[ L_1 = \left\{ \frac{\alpha_B}{\alpha_M} (L - c_A G_0 + c_A G_1) \left( 1 + \frac{\alpha_B}{\alpha_M} \right)^{-1} \right\} \leq L_1 \]  

28
where $L_1$ is the lower bound of $L_1$ shown in Figure 3. In some cases, mobility of workers may lead to the outbound of the feasible range of $L_1$, say point $E'$. This can happen, for example, when $a_1/a_0$ (relative productivity advantage of generic agriculture in the periphery) and $T_B^{α_B}T_M^{−α_M}$ are sufficiently small.

![Figure 3: Long-run equilibrium](image)

6 Concluding remarks

In this paper, we extended the NEG model introducing the brand agriculture sector. We focused on the core-periphery spatial structure with hub-and-spoke
transport system, where manufacturing is concentrated in the core and the regions in the periphery produce brand agriculture products. Our result shows that the brand agriculture is sustainable in the remote periphery provided that these products are sufficiently differentiated. Although the rural periphery has been considered as the supplier of the generic primary commodities in our common perception, we contend that the innovation efforts in developing differentiated agriculture and implementing appropriate measures to facilitate the market access of such products enable the periphery to increase its income. The Proposition 1 states that disadvantageous transport condition of the periphery can be overcome through product differentiation and also by taking advantage of low fixed cost there. We found that

In contrast to the general perception of development strategy of thinking the industrialization in cities first and then expecting the trickle-down of income growth toward rural sector, the approach in this paper highlights the necessity of thinking up side down: thinking first the innovation to prosper based on the local advantage in each rural area. The NEG literature has emphasized that the power of mega cities will increase in the era of globalization. It also refers to the increasing development potential of well-connected medium-sized cities, or "near periphery", as the congestion in mega cities grows. Meantime, the agricultural hinterland, or "far periphery", has been paid little attention in the literature, and the widening income gap between the core and the periphery has been recognized as a serious problem. While we should cast more critical thinking on the neoclassical theory based trickle-down strategy, the NEG approach has not been able to provide meaningful policy implication to this burning question due to the simplistic assumption on the rural sector. Our approach suggests
a promising research direction to fill that gap.

Appendix

Appendix 1

In section 3.2, we examined equilibrium conditions of the factor market (land and labor) in each region and market clearing of $A$-product and $M$-products. Hence, according to the Walras’ law, the remaining $B$-products market should be also in equilibrium in our general equilibrium setting. However, it is appropriate to examine whether this condition is really satisfied to check the consistency of the model.

Following (31), we establish the equilibrium condition of $B$-product market such that bid rent given by (21) should be equal to the zero-profit land rent paid by $A$-good farmers. In this case $R^B_1$ is specified as,

$$R^B_1 = k_B \left[Y_0 P_B^{-\frac{(\sigma_B-1)}{\sigma_B}} (P^B_0)^{\frac{1}{\sigma_B}}ight] + mY_1 \left(P^B_1\right)^{\frac{1}{\sigma_B}} \left\{(m - 1) T_B^{-2(\sigma_B-1)} + 1 \right\}^{\frac{1}{\sigma_B}} - c_B w_1 \quad (A1)$$

Then, we substitute (43) and (44) into (A1) and obtain

$$R^B_1 = k_B \left(n^B_1\right)^{-\frac{1}{\sigma_B}} \left(\frac{c_B w_1 + R_1}{P^B}\right)^{\frac{(\sigma_B-1)}{\sigma_B}} \left[Y_0 + mY_1 \right]^{\frac{1}{\sigma_B}} - c_B w_1$$
This can be rearranged as

\[ \left( \frac{cw_1 + R_1^B}{cw_1 + R_1} \right)^{\alpha_B} = \left( \frac{(k_B)^{\alpha_B} (\rho_B)^{-(\sigma_B - 1)}}{n_1^{B^*}} \right) \frac{Y_0 + mY_1}{cw_1 + R_1} \]  \hspace{1cm} (A2)

Focusing on the right hand side, we substitute (42) for \( R_1 \) and (62) for \( w_1 \) while using (64) for \( P_A^1 \). Then we obtain

\[ cw_1 + R_1 = \frac{\alpha_B}{\alpha_M} \frac{L_0 - c_AG_0}{L_1 - c_AG_1} (c_B - c_A) \]  \hspace{1cm} (A3)

Substitutions of (62) and (64) into (47) and (48) yield

\[ Y_0 + mY_1 = \frac{L_0 - c_AG_0}{\alpha_M} \]  \hspace{1cm} (A4)

Using (55), we can obtain

\[ \frac{(k_B)^{\alpha_B} (\rho_B)^{-(\sigma_B - 1)}}{n_1^{B^*}} = \frac{\alpha_B (c_B - c_A)}{L_1 - c_AG_1} \]  \hspace{1cm} (A5)

Combining (A3), (A4), and (A5), (A2) is boiled down to

\[ \left( \frac{R_1^B + cw_1}{R_1 + cw_1} \right)^{\alpha_B} = 1 \]

which requires

\[ R_1^B = R_1. \]

This proves that \( B \)-product farmers are in zero profit equilibrium and all equilibrium solutions which we obtained for this geographic configuration are consistent.
Appendix 2

Substitution of (71) into (72) yields

\[
\Omega_B^0 = \frac{\rho_B}{(c_B + R_0) f_B} \left( \frac{\alpha_B Y_0 (P_0^B)^{\sigma_B - 1}}{(c_B + R_0)^{\sigma_B - 1}} + \frac{\alpha_B m Y_1 (P_1^B)^{\sigma_B - 1}}{[(c_B + R_0) T_B]^{\sigma_B - 1}} \right). \quad (A6)
\]

In this expression, the denominator of the first term of the right hand side represents the fixed cost of production. Thus, the first term together shows the fixed cost advantages of region 0 in brand agriculture production, which is larger as the fixed cost is smaller. The first term inside the braces represents effective size of the demand at market in region 0 provided the potential market size in region 0, \(\alpha_B Y_0 (P_0^B)^{\sigma_B - 1} \), discounted by the marginal supply cost, \((c_B + R_0)^{\sigma_B - 1}\). Likewise, the numerator and the denominator of the second term in the braces respectively refers to the effective demand in the periphery market and the marginal supply cost from region 0. Substituting further (43) and (44) into (A6) yields

\[
\Omega_B^0 = \frac{\alpha_B}{n_B^2 \sigma_B f_B (c_B + R_0)} \left( \frac{c_B w_1 + R_1}{c_B + R_0} \right)^{\sigma_B - 1} \times \left[ \frac{Y_0 (T_B)^{\sigma_B - 1}}{m} + \frac{m Y_1}{1 + (m - 1) (T_B)^{\sigma_B - 1}} \right]. \quad (A7)
\]

Likewise, the potential function of \(B\)-sector in region 1 is given by

\[
\Omega_B^1 = \frac{x_1}{x^*} = \frac{\alpha_B}{n_B^2 \sigma_B f_B (c_B w_1 + R_1)} \left[ \frac{Y_0}{m} + Y_1 \right].
\]

Clearly, \(\Omega_B^1 = 1\) since all existing farmers of \(B\)-sector in region 1 are operating
under zero profit equilibrium. Substituting this into (A7), we obtain (74).

Appendix 3

Using (24) and (77), we obtain:

\[
\Omega^M_1 = \frac{(\rho^M)}{w_1 c_M f_M} \left[ \frac{\alpha_M Y_0 (P_0^M)^{\sigma_M-1}}{(w_1 c_M T_M)^{\sigma_M-1}} + \frac{\alpha_M Y_1 (P_1^M)^{\sigma_M-1}}{(w_1 c_M)^{\sigma_M-1}} \right] + \frac{\alpha_M (m - 1) Y_1 (P_1^M)^{\sigma_M-1}}{(w_1 c_M (T_M)^2)^{\sigma_M-1}}
\]

Likewise, the potential function in region 0 is given by

\[
\Omega^M_0 = \frac{(\rho^M)}{c_M f_M} \left[ \frac{\alpha_M Y_0 (P_0^M)^{\sigma_M-1}}{(c_M)^{\sigma_M-1}} + \frac{\alpha_M m Y_1 (P_1^M)^{\sigma_M-1}}{(c_M T_M)^{\sigma_M-1}} \right]
\]

It is obvious that \( \Omega^M_0 = 1 \) because all active \( M \)-firms in region 0 earn zero profit.

Using this result and by substitution of (45), (46), (62) and (69) into (A8), we obtain (80).

References

