Location and organization choice of firms^{*}

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November, 2009

Abstract

Typical implicit assumption on increasing returns to scale sector is that firms can produce and sale only at one place. We explicitly introduce multi-plant case and examine location equilibrium with decreasing transpiration costs in a two-region model of monopolistic competition with mobile entrepreneurs. The difference between single-plant and multi-plant firms lies in export-fixed cost and set-up fixed cost of multi-plant. We show that the organization change is different under symmetric distribution and core-periphery structure of firms and that at certain transportation costs, firms change their organization type from multi-plant to single-plant and, with further decrease in transportation costs.

JEL Classification : D21, F12, L23, R12,

Keywords : Economic Integration, Organization of Production, Horizontal FDI, Export Fixed Cost, Transaction Cost

^{*}The author thanks Masahisa Fujita, Jing Li, Giordano Mion, Tomoya Mori, Frédéric Robert-Nicoud and Jacque Thisse for their helpful discussions and encouragement. He is grateful to le Commissariat Général aux Relations Internationales de la Communaute Française de Belgique for their financial support and is also grateful to research support from CORE, Université Catholique de Louvain, Belgium in 2008, where most parts of this paper were conducted. The usual disclaimer applies.

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1 Introduction

As is confirmed by many studies, in regional trade and international trade, "geography matters". Krugman (1991) sheds lights on geography in international trade. Krugman and Venables (1995), Puga and Venables (1999), Fujita, Krugman and Venables (1999), Ottaviano, Tabuchi and Thisse (2002), and Forslid and Ottaviano (2003) are also on the same direction with analytical derivation on stability analysis. Baldwin, Forslid, Martin, Ottaviano and Robert-Nicoud (2003) is also contributed in this respect. There are the studies on the location choice of firms and the stability of the location equilibria. Including these studies, most of the previous studies in international trade based on differentiated goods assume that a differentiated goods is produced by one firm and that the production is held at one place.

Keeping the above assumptions, even under heavy transportation costs, firms have to choose one location to produce and deliver their products to the region and to the other region. However, as is pointed out by Brainard (1997), firms faces proximity-concentration trade-off¹ and firms change their plant configuration, depending on the degree of trade barriers. When we relax the single-plant assumption, we could easily imagine the location equilibrium with multi-plants in each regions when trade barriers and (or) transportation costs are very high. This configuration to operate plants in multi-regions is described as horizontal FDI. As long as we keep the single plant assumption, we could not analyze the firms' choice and effects including horizontal FDI.

Instead of keeping this single-plant assumption, when we restrict ourselves on the alternative assumption that *the production should be held at every place*. The impact of transport costs vanishes from the analysis. Then we could say that "geography doesn't matter". Both assumptions are the extreme cases for the analysis on international trade. While there are substantial development in theory of international trade, the issues with multinational enterprises are still left aside.

The aim of this paper is to propose some simple modifications, based on Forslid and Ottaviano (2003) which enables closed form solutions for Fujita et al. (1999). Our simple modification enables us to analytically analyze the choice of firms conducting multinational business, services and productions. We explicitly introduce the organization choice on the configuration of plants. As we relax the assumption on the number of plants, we show that "not only geography but also organization matters".

Markusen and Venables (1998) and Raybaudi-Massilia (2000) also analyze behavior of multinational firms and the choice of horizontal FDI. However, Krugman and Venables (1995) and Puga and Venables (1999) showed the stability the analysis with simulation results only. The others derive analytical results. Ekholm and Forslid (2001), Toulemonde (2008), Toule-

¹While proximity to market enables firms to earn larger profit, firms can exploit scale economies to concentrate their production at one place. Toulemonde (2007) also gives a short reasoning on this trade off.

monde (2007), and Behrens and Picard (2007) are some studies which share the same spirit with ours. However Toulemonde (2008), Toulemonde (2007) and Behrens and Picard (2007) also model this point in similar but different strategy. They adopt Footloose Capital model where location decision is made in terms of nominal profit. The clear difference comes from theirs and ours lies on the stability of symmetric firms' distribution and the mixed patterns. Instead of capital, we assume entrepreneurs who determine the location and organization of firms in evaluating not nominal term but real term.

The rest of this paper is organized as follows; in section 2, a two-region model without organization choice is constructed with symmetric regions as a benchmark. In section 3, organization choice is introduced. Possible caveats associated with the delimitation of studying location choice are discussed in the final section.

2 Location choice without organization choice

The economy is composed of symmetric two regions 1 and 2. There are two production factors: entrepreneurs and immobile workers. In this economy, L unit of immobile workers and H unit of entrepreneurs are endowed. While immobile workers are equally distributed between regions and are immobile, entrepreneurs can choose the region to stay and the share of entrepreneurs in region 1 is expressed by λ .

2.1 Consumers

We assume that preference is identical across all workers in both regions and is expressed by a combination of Cobb-Douglas and CES forms of utility function which is written as

$$U = \frac{A^{1-\mu}Q^{\mu}}{\mu^{\mu} \left(1-\mu\right)^{1-\mu}} \tag{1}$$

where A stands for the consumption of agriculture good, q(i) is the consumption of manufactured good variety $i \in [0.N]$ and Q is an index of manufactured good consumption $Q = \left[\int_0^N q(i)^{\frac{\sigma-1}{\sigma}} d_i\right]^{\frac{\sigma}{\sigma-1}}$. N indicates the number of differentiated manufactured goods and $\sigma > 1$ is the elasticity of substitution between any pair of manufactured goods. The share of expenditure on manufactured goods is μ and the share of expenditure on agriculture good, and the price of a differentiated manufactured good, and the price index of manufactured goods in region $r, P = \left[\int_0^N p(i)^{1-\sigma} d_i\right]^{\frac{1}{1-\sigma}}$. Then we could derive the demand function for a differentiated manufactured good and the indirect utility function as,

$$q_r(i) = \mu \left(\frac{P_r}{p(i)}\right)^{\sigma} \frac{Y_r}{P_r}$$
(2)

$$V_r = (p^A)^{-(1-\mu)} P_r^{-\mu} w_r \quad \text{immobile worker} \tag{3}$$

$$V_r = (p^A)^{-(1-\mu)} P_r^{-\mu} W_r \quad \text{entrepreneur} \tag{4}$$

Wages for entrepreneurs and immobile worker are expressed by W_r, w_r . Lower subscript exhibits the location, $r \in [1, 2]$. Then using the share of entrepreneurs in region r, λ , we may write regional total income as

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$$Y_r = \frac{L}{2}w_r + W_r H\lambda \tag{5}$$

While the distribution of entrepreneurs is endogenous, for the analysis of symmetric regions, we set the distribution of immobile workers as half and half.

2.2 Agriculture

Agriculture sector produces a homogeneous good under perfect competition and constant returns to scale with using only labour input. This good is traded costlessly. Thus we take agriculture as numéraire and normalize the wage, namely workers' wage in region 1 into one, $p_A = w_A = w_B = 1$.

2.3 Single-plant firm (exporter)

In manufacturing sector, we assume that firms are imperfectly competitive à la Dixit-Stiglitz and produce differentiated goods. Production of a differentiated good incurs one unit of entrepreneurs as fixed costs and one unit of immobile workers as marginal labour requirement. Interregional trade of manufactured goods is marked by "iceberg" transport costs and selling one unit in the other region requires $\tau \geq 1$ units to be shipped. For later reference, we posit $\phi = \tau^{1-\sigma}$ as alternative measure of transport costs. We may call ϕ as trade freeness. When transport costs are high, ϕ takes the value close to zero. Then increasing ϕ expresses the decreasing transport costs and no transport costs can be expressed by $\phi = 1$. When the single-plant firm locates in region r, it faces the demand from the same region, $\left(\frac{P_r}{p_r(i)}\right)^{\sigma} \frac{\mu Y_r}{P_r}$, and the demand from the other region to export, $\left(\frac{P_s}{p_s(i)}\right)^{\sigma} \frac{\mu Y_s}{P_s} \phi$. Then the total demand for a differentiated good can be written as,

$$q_r(i) = \left(\frac{P_r}{p_r(i)}\right)^{\sigma} \frac{\mu Y_r}{P_r} + \left(\frac{P_s}{p_s(i)}\right)^{\sigma} \frac{\mu Y_s}{P_s}\phi$$
(6)

When single-plant firms export their products to the other region where they do not locate, they incur transport costs. Thus the price indices can be written as

$$P_{A}^{1-\sigma} = N\left[\lambda \int_{0}^{1} p(i)^{1-\sigma} d_{i} + (1-\lambda)\phi \int_{0}^{1} p(i)^{1-\sigma} d_{i}\right]$$
(7)

$$P_B^{1-\sigma} = N \left[\lambda \phi \int_0^1 p(i)^{1-\sigma} d_i + (1-\lambda) \int_0^1 p(i)^{1-\sigma} d_i \right]$$
(8)

where N expresses the total number of firms, $N = \frac{H}{(1+\delta)f}$. As is mentioned in the introduction, all imperfectly competitive firms without organization choice are assumed to be exporters with single-plant. We assume specific *fixed-export costs*. When a single-plant firm locates in one region and establishes only one plant there, entrepreneurs have to set up an exporting facility. This establishment cost for exporting is costly and is to be written as $\delta_{rs} = \delta > 0, r \neq s$. This specification of additional fixed cost could clarify the role of cost difference between single and multi-plant firms. The profit function of a differentiated good firm with single-plant in one region r can be written as

$$\pi_r^S(i) = (p_r(i) - w_r) q_r(i) - (1 + \delta) W_r^S(i)$$
(9)

The single-plant firm producing variety *i* chooses its mill price to maximize profit $\pi_r(i)$. The price resulting from the maximization is a markup over marginal costs:

$$p_r\left(i\right) = \frac{\sigma}{\sigma - 1} w_r \tag{10}$$

Using the optimal prices both in profit function and in price index, and normalizing labour wage in competitive sector as one, $w_r = w_s = 1$, we could obtain the equilibrium profits as,

$$\pi_r^S(i) = \frac{\mu}{\sigma N} \left[\frac{Y_r}{\Delta} + \frac{Y_s}{\Delta^*} \phi \right] - (1+\delta) W_r^S(i)$$
(11)

where Δ is the bracket of the price index, (7), in region 1, Δ^* is the equivalent of region 2. We use λ as the share of firms in region 1. With normalizing the population of entrepreneurs into one, we have the total number of firms as, $N = 1/(1 + \delta)$. Then the share of entrepreneurs in a region is the same with the share of firms in a region. Imposing the free entry condition on this monopolistic sector with the equation in (11) and substituting the total number of firms, we could find entrepreneurs' reward of an exporting firm in region r with a single-plant as,

$$W_r^S(i) = \frac{\mu}{\sigma} \left[\frac{Y_r}{\Delta} + \frac{Y_s}{\Delta^*} \phi \right]$$
(12)

where
$$\Delta = [\lambda + (1 - \lambda)\phi]$$
, and $\Delta^* = [\lambda\phi + (1 - \lambda)]$ (13)

Using (5) and (12), we could perform the analysis on location equilibria.

2.4 Location equilibrium

It is one of the main concerns that how distribution of entrepreneurs evolves as transport costs are steadily decreasing. Migration dynamics is characterized by the relative real wage of entrepreneurs. It is straight forward to obtain the real wage differential. Using the wage equations in Appendix I and the labour market clear condition on entrepreneurs, $N = H/(1 + \delta)$

, we obtain the relative real wage as,

$$\frac{\varpi_A^S}{\varpi_B^S} = \frac{W_A^S}{W_B^S} \left(\frac{P_A}{P_B}\right)^{\frac{\mu}{\sigma-1}} \\
= \frac{(1-\lambda)\left(\mu+\sigma\right)\phi^2 + 2\sigma\lambda\phi + (1-\lambda)\left(\sigma-\mu\right)}{\lambda\left(\mu+\sigma\right)\phi^2 + 2\sigma\left(1-\lambda\right)\phi + \lambda\left(\sigma-\mu\right)} \left(\frac{\lambda+(1-\lambda)\phi}{\lambda\phi+(1-\lambda)}\right)^{\frac{\mu}{\sigma-1}} \quad (14)$$

When this relative real wage is above (below) one, region 1 (2) is preferred by entrepreneurs. In order to examine the stability of the distribution of entrepreneurs, differentiating this equation (14) minus one respect to λ and evaluating at symmetric equilibrium ($\lambda = 1/2$), we obtain the break point:

$$\phi^B = \frac{(\sigma - \mu) \left(\sigma - \mu - 1\right)}{(\sigma + \mu) \left(\sigma + \mu - 1\right)} \tag{15}$$

When trade openness between regions are higher than ϕ^B , the symmetric equilibrium is unstable. To avoid the case that even under infinite transport costs agglomeration equilibrium dominates to symmetrically dispersed equilibrium, it is assumed to hold the "no-black-hole" condition², $\mu < \sigma - 1$. While we put the fixed export costs, since it cancels out with the total number of firms, the result is exactly the same with Forslid and Ottaviano (2003). Using these wage equations, we obtain equation (14).

3 Location and organization choice

In this section, we study the location and organization choice of firms. We only modify the assumption on the number of plants. Introduction of multi-plant firms means an additional choice for entrepreneurs. We explicitly put the share of entrepreneurs in region 1 and 2 as λ and Λ . Furthermore, the share of entrepreneurs in multi-plant firms, single-plant firms in each region as, m_r , $(1 - m_r)$. Since the sum of shares must be one, the share of entrepreneurs in region 2 is expressed as $\Lambda \equiv 1 - \lambda$. For expositional simplification, we utilize Λ except when we evaluate the share of firms explicitly. Nominal rewards to entrepreneurs in multi-plant firms are assumed to be the same across regions. Following these specifications, we rewrite regional income in (5) as

$$Y_1 = \frac{L}{2} + \left((1 - m_1) W_1^S + m_1 W^M \right) H\lambda$$
(16)

$$Y_2 = \frac{L}{2} + \left((1 - m_2) W_2^S + m_2 W^M \right) H\Lambda$$
(17)

While single-plant firms export the other region where they do not locate, multi-plant firms can serve both regions without incurring transport costs. Thus the price index of the

 $^{^{2}}$ See Forslid and Ottaviano (2003), for the condition of original core-periphery model.

varieties sold in region r, P_r is expressed as

$$P_A^{1-\sigma} = N\left[\left(\lambda \left(1 - m_1\right) + \phi \Lambda \left(1 - m_2\right) + \left(\lambda m_1 + \Lambda m_2\right)\right) \int_0^1 p\left(i\right)^{1-\sigma} d_i \right]$$
(18)

$$P_B^{1-\sigma} = N \left[\left(\phi \lambda \left(1 - m_1 \right) + \Lambda \left(1 - m_2 \right) + \left(\lambda m_1 + \Lambda m_2 \right) \right) \int_0^1 p\left(i \right)^{1-\sigma} d_i \right]$$
(19)

First term expresses the price index of firms locating in region 1 and the second term expresses the price index of firms locating in region B. The last expression is the price index of multi-plant firms. Without the loss of generality, we normalize the population of mobile entrepreneurs and immobile workers as one by each, L = H = 1.

3.1 Multi-plant producer (horizontal FDI)

Multi-plant firms are also depicted by imperfectly competitive firms à la Dixit-Stiglitz and produce a differentiated good. The only modification from the single-plant exporter is that establishment of multi-plant incurs additional fixed cost, $\alpha > 0$. This fixed costs, α , include the costs for construction of the networks, as well as the costs for establishing a subsidiary in the other region and the duplicate overhead production costs³. For the production, multiplant firms employ immobile workers in both regions for variable input. Contrast to the cost function of single-plant firms, since multi-plant firms locate in each region, the shipment of products by multi-plant firms doesn't incur transport costs, $\delta_{rr} = 0$, r = 1 and 2, nor export fixed cost, $\delta = 0$. Thus they face the demand from each regions without transport costs. Taking each regional demand as given in (2), multi-plant firms maximize their profit. Then the output and the profit function of a multi-plant firm can be written as

$$q_{rr}^{M}(i) = \left(\frac{P_{r}}{p_{r}(i)}\right)^{\sigma} \frac{\mu Y_{r}}{P_{r}}, \qquad q_{ss}^{M}(i) = \left(\frac{P_{s}}{p_{s}(i)}\right)^{\sigma} \frac{\mu Y_{s}}{P_{s}}$$

$$q_{r}^{M}(i) = q_{rr}^{M}(i) + q_{ss}^{M}(i)$$

$$(20)$$

$$\pi^{M}(i) = (p_{r}(i) - w_{r}) q_{rr}^{M}(i) - (p_{s}(i) - w_{s}) q_{ss}^{M}(i) - (1 + \alpha) W^{M}(i)$$
(21)

where upper subscript M indicate multi-plant firms and W^M is a entrepreneurs' reward in multi-plant firms in region r. Since location is indifferent for multi-plant firms, their profit function and their wage for entrepreneur do not include region specific subscript. A multiplant firm producing variety i chooses its mill price to maximize profit $\pi_r^M(i)$ respect to each region using discriminatory price. The price resulting from the maximization is a markup

 $^{^{3}}$ Fujita and Gokan (2005) assume that the fixed cost of a multi-plant firm to build an additional plant is larger than the fixed costs of the single plant. Toulemonde (2008) explain that several factors affect the fixed costs of a multinational.

over marginal costs as^4 ,

$$p_r(i) = \frac{\sigma}{\sigma - 1} w_r, \quad r = 1, 2 \tag{22}$$

Using the optimal prices both in profit function and in price index, normalization of labour wage in competitive sector as one, $w_r = w_s = 1$, and a given distribution of firms, the equilibrium profits can be obtained as follows

$$\pi^{M}(i) = \frac{\mu}{\sigma N} \left[\frac{Y_{r}}{\Delta} + \frac{Y_{s}}{\blacktriangle} \right] - (1+\alpha) W^{M}(i)$$
(23)

where
$$\triangle = [\lambda (1 - m_1) + \Lambda (1 - m_2) \phi + (\lambda m_1 + \Lambda m_2)],$$

and $\blacktriangle = [\lambda (1 - m_1) \phi + \Lambda (1 - m_2) + (\lambda m_1 + \Lambda m_2)]$

where \triangle and \blacktriangle expresses the brackets of price indices, (18), in region 1 and 2, $P_1 = \triangle^{\frac{1}{1-\sigma}}$, which reflect the magnitudes of multi-plant firms. Assuming the existence of potential entrants ensures that the operating profit of suppliers is set to zero, the wage of entrepreneurs are obtained from the zero profit condition of (23). Single-plant firms' offer to entrepreneurs are obtained from the same procedure as in (11) except that the price index is not the same. Then, we obtain the Entrepreneurs' reward for single-plant firm *i* and multi-plant firm *j* as

$$W_r^S(i) = \frac{\mu}{\sigma (1+\delta) N} \left[\frac{Y_r}{\Delta} + \frac{Y_s}{\blacktriangle} \phi \right]$$
(24)

$$W^{M}(j) = \frac{\mu}{\sigma (1+\alpha) N} \left[\frac{Y_{r}}{\Delta} + \frac{Y_{s}}{\blacktriangle} \right]$$
(25)

Since entrepreneurs could seek for the highest reward region and firms, if the offered wage is less than the others', the firm cannot enter or remain the market because of the lack of fixed requirement. This could be interpreted as a bidding process of Entrepreneurs' reward. In equilibrium, firms offer the same wage in the same region. Under the monotonic case of single-plant firms, equilibrium wage condition is $W_r^S(i) = W_r^S(j) = W_r^S$, $i \neq j$ and under the monotonic case of multi-plant firms, equilibrium wage condition is $W^M(i) = W^M(j) = W^M$, $i \neq j$. On the other hand, under the mixed case of both firms, equilibrium wage must hold $W_r^S(i) = W_r^M(j)$, $i \neq j$. When there exists only one pattern, not mixed patterns, this equilibrium equality condition on wage is applied to (24) for any single firms under the monotonic single firms case, and it is applied to (25) for any multi-plant firms under the monotonic multi-plant firms case. In each cases, the labour market clear condition of entrepreneurs implies the total number of firms as $N = 1/(1 + \delta)$ for only single plant case and $N = 1/(1 + \alpha)$. On the other hand, when there exists mixed case, the total number of firms is $N = \frac{1}{((1+\delta)(\lambda(1-m_1)+\Lambda(1-m_2))+(1+\alpha)(\lambda m_1+\Lambda m_2))}$. When all structures of two regions are symmetric, including the share of multi-plant firms in the region, the total number of

⁴Note that suppose there is a wage gap between two regions, the prices chosen by multi-plant firm are different across regions.

firms can be written as, $N = \frac{1}{(1+\delta)(1-m)+(1+\alpha)m}$. Note that when we restrict ourselves with the assumption that there is no organization choice and all firms be multi-plant firms, there is no effect from transportation costs. Thus agglomeration economies do not emerge. For simpler notation, in the reminder of this paper, we denote κ as an inverse of the first term of (24) and (25). Since the first term of (24) and (25) reflects the share of entrepreneur's reward in profit, it is always positive and the inverse, κ , is always larger than one.

3.2 Location equilibrium

While location choice is based on the real wage differential, organization choice is based on the nominal wage. It is because the choice of multi-plant firms from single-plant firms doesn't require location change. Before examining the stability of symmetric structure, we observe how the share of multi-plant firms affect the relative real wage at symmetric structure. In the case without organization choice, no multi-plant case, nominal wage differential, w_1^S/w_2^S , is always one. On the other hand, in the case with organization choice, the relative real wage become a function of multi-plant firms' share in each region. When entrepreneurs face the organization choice, their decision is based on the nominal wage differential. It is because they can change the firm's organization without changing the location. Firstly we solve the equations for regional incomes and wages for entrepreneurs. Then we examine the stability of symmetrically dispersed location equilibrium and of the organization of firms. Furthermore, we see the stability of core-periphery structure location equilibrium and of the organization. These location equilibria are endogenously determined as market outcomes.

Using four equations, (24), (25), and their symmetric expression for the other region, we obtain $W_A^S, W_B^S, W_r^M, Y_A, Y_B$ explicitly (See Appendix II). Then we obtain the relative real wage as follows.

$$\frac{W_1^S}{W^M} = \frac{\kappa \left(\mathbf{A} + \phi \Delta\right) \Gamma + (1 - \phi) \left(\lambda m_1 - \Lambda m_2\right) - \Lambda \left(1 - \phi\right) \left(\phi + 1\right) \left(1 - m_2\right) \Gamma}{\kappa \left(\mathbf{A} + \Delta\right) - \lambda \left(1 - m_1\right) \left(1 - \phi\right) - \Lambda \left(1 - m_2\right) \left(1 - \phi\right)}$$
(26)

$$\frac{W_2^S}{W^M} = \frac{\kappa \left(\Delta + \phi \blacktriangle\right) \Gamma + (1 - \phi) \left(\Lambda m_2 - \lambda m_1\right) - \lambda \left(1 - \phi\right) \left(1 + \phi\right) \left(1 - m_1\right) \Gamma}{\kappa \left(\blacktriangle + \Delta\right) - \lambda \left(1 - m_1\right) \left(1 - \phi\right) - \Lambda \left(1 - m_2\right) \left(1 - \phi\right)}$$
(27)

$$\frac{W_1^S}{W_2^S} = \frac{\kappa \left(\mathbf{A} + \phi \Delta\right) + \Gamma \left(1 - \phi\right) \left(\lambda m_1 - \Lambda m_2\right) - \Lambda \left(1 - \phi\right) \left(\phi + 1\right) \left(1 - m_2\right)}{\kappa \left(\Delta + \phi \mathbf{A}\right) + \Gamma \left(1 - \phi\right) \left(\Lambda m_2 - \lambda m_1\right) - \lambda \left(1 - \phi\right) \left(1 + \phi\right) \left(1 - m_1\right)}$$
(28)

where $\Gamma \equiv (1 + \delta) / (1 + \alpha)$, we could interpret this as the differential between fixed costs for newly establishment of plants and that for exporting and call it the differential of transaction costs. When we assume $0 \le \delta < \alpha \le 1$, we have $\Gamma \in [1/2, 1)$. In the beginning when transport costs are very high, all firms are multi-plant, $m_1 = m_2 = 1$. Substituting this distribution condition of multi-plant firms into above, we obtain the nominal wage differential against the wage for multi-plant firms boiled down into as follows:

$$\frac{W_1^S}{W^M}\Big|_{\lambda=\Lambda=\frac{1}{2},m_1=m_2=1} = \frac{(1+\phi)(1+\alpha)}{2(1+\delta)}$$
(29)

Note that we could obtain identical result with the case that we just pose the condition of symmetry in the share of multi-plant firms, $m_1 = m_2 = m$. It is obvious that this is an increasing function of ϕ and when (29) is equal to one, firms change their organization from multi-plant into single-exporting. The critical value of transport costs for organization change is not a function of the share of multi-plant firms. Thus under symmetric distribution, we cannot observe the mixed pattern of organization. Solving (29) equal to one for ϕ , we obtain

$$\phi^{MS} = 2\Gamma - 1 = 2\left(\frac{1+\delta}{1+\alpha} - \frac{1}{2}\right), \quad \text{where} \quad \Gamma \equiv \frac{(1+\delta)}{(1+\alpha)} \tag{30}$$

As long as all firms are multi-plant firms $\phi < \phi^{MS}$, both the nominal wage for entrepreneurs and price index in each region are unchanged. Since the measure of transport costs is between 0 and 1, $\phi \in [0, 1]$, we need to clarify the condition of organization change. There are three cases depending on the transaction costs differential in Γ . When $0 \le \delta < \alpha \le 1$, that is $\Gamma \in [1/2, 1)$, (30) has always one interior solution in the range of $\phi^{MS} \in [0, 1)$. This is the most various case in location equilibria, which we adopt the assumption of the differential of transaction costs and we discuss later. Suppose $\delta = \alpha$, then we have $\Gamma = 1$. Thus $\phi^{MS} = 1$. Although multi-plant is always the stable organization of firms, only when there is no transportation costs, it is indifferent for all firms to change their organization. Suppose $0 \le \alpha < \delta \le 1$, that is $\Gamma \in (1, 2]$, then we have always $\Gamma > 1$. Thus $\phi^{MS} > 1$ always holds. This means that when export fixed cost is larger than the establishment cost for multi-plant, multi-plant is always the stable organization of firms and there is no organization change. Then we could summarize some reasoning as follows.

Lemma 1 Organization change surely occurs once at certain transport costs, $\phi = \phi^{MS}$, as long as $0 \le \delta < \alpha \le 1$ holds.

Lemma 2 The smaller (larger) the difference between the two transaction costs, the more multi-plant is organizationally stable (unstable) under low transport costs.

For the closer observation, we examine the stability of this organization change when all are multi-plant firms. Suppose the transportation costs decrease more than the critical value of organization change, $\phi^{MS} < \phi$, at least, some firms change their organization. This change, decrease in the share of multi-plant firms (m_1 or m_2), affects the incentive of other firms in both regions. In order to find this effect, we make the differentiation of the nominal wage differential, (26) to (28), with respect to m_1 and m_2 . The results are listed in the Appendix II and as follows.

$$\left. \frac{d}{dm_r} \frac{W_r^S}{W^M} \right|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1} > 0 \tag{31}$$

$$\frac{d}{dm_r} \frac{W_r^S}{W^M} \bigg|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1} = -\frac{d}{dm_s} \frac{W_r^S}{W^M} \bigg|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1}$$
(32)

From the expression in (31), while the organization change by some firms in region r induces the other firms in the same region, not to change their organization, it urges the firms in region s, to change their organization. Then this organization change in region s affects the firms in region r, vice versa. As is expressed in (32), the magnitude of these mutual interactions is just equal. Thus these effects are totally canceled out and have no effect on ϕ^{MS} . It means that all firms change their organization at the same time when they face the critical transport costs, $\phi = \phi^{MS}$. These are summarized by the next equation and following lemma and proposition.

Lemma 3 Under symmetric distribution of firms, when the share of multi-plant firms in each region is the same, the organization change occurs instantaneously.

Then we could confirm the following proposition.

- **Proposition 1** Consider monopolistic firms that have two choices in their production location, single-plant exporting or multi-plant, under symmetric distribution of firms and with decreasing transport costs.
- (i) If fixed cost for exporting is larger than that for multi-plant, $(0 \le \alpha < \delta \le 1)$, all firms choose multi-plant and never change their organization even for lower transport costs.
- (ii) If fixed cost for exporting is the same as that for multi-plant, (δ = α), all firms choose multi-plant and only when transportation costs vanishes, it is indifferent for all firms to change their organization, φ = φ^{MS} = 1.
- (iii) If fixed cost for exporting is smaller than that for multi-plant, $(0 \le \delta < \alpha \le 1)$, all firms choose multi-plant under high transport costs and, at certain transport costs, they change their organization from multi-plant to exporting.

Moreover, when $\phi^B < \phi^{MS}$ holds, symmetric equilibrium is stable even under $\phi^B \le \phi \le \phi^{MS}$, where the symmetric location equilibrium is unstable under the single-plant assumption.

This proposition implies one interesting scenario. Starting from the symmetrically dispersed equilibrium, all firms change their organization from multi-plant to single-plant at once and the economy is identical to the case we observed in the previous section. Thus the economy experiences the catastrophic change of regional structure and exhibits agglomeration economies.

So far, we have focused on the stable symmetric distribution case, where the share of single-plant firms in each region is the same, $\lambda = \Lambda = 1/2$ and organization change. When the symmetric distribution becomes unstable, all firms agglomerate in one region and coreperiphery structure of firms emerges. Under core-periphery structure, the results are to be modified. When the economy changes their distribution from symmetrically dispersed equilibrium to core-periphery equilibrium, firms may face organization choice again. We turn to envisage the case of core-periphery structure and organization choice. Since the organization choice is determined within one region, the choice solely depends on the nominal wage differential in the region. Substituting the distribution condition of multi-plant firms and entrepreneurs, $\lambda = 1$, $\Lambda = 0$, $m_1 = 1$, $m_2 = 0$, into (26), we obtain the nominal wage differential against the wage for multi-plant firms boiled down into as follows⁵:

$$\frac{W_1^S}{W^M}\Big|_{\lambda=1,m_1=1,m_2=0} = \frac{1}{2} \left(\frac{(1+\phi)(1+\alpha)}{(1+\delta)} + \frac{\mu}{\sigma} \frac{(1-\phi)}{(1+\alpha)(1+\delta)} \right)$$
(33)

$$\frac{d}{dm_1} \frac{W_1^S}{W^M} \bigg|_{\lambda=1,m_1=1,m_2=0} = \frac{(1-\phi)}{8(1+\alpha)} \left((1+\delta)(1-\phi) + \frac{\mu}{\sigma} \left(\frac{2}{(1+\delta)} - \frac{(1+\phi)}{(1+\alpha)} \right) \right) > (\mathbf{3}4)$$

Comparing to the result from the nominal wage differential under symmetric distribution, (29), the magnitudes of demands on differentiated goods, $\frac{\mu}{\sigma}$, appear in the second term in (33). The parameters expresses the preference on differentiated goods and the substitution parameter between any differentiated goods and briefly expresses that the magnitudes of home market effect. While under symmetric distribution there are mutually interacted effects from the organization change in each regions and the effects cancel out each other as in (32), under core-periphery structure the absence of the competing region allows the core region to exploit, so called, the agglomeration rent stemming out of home market effect.

Then we further analyze on organization change under core-periphery structure. We could imagine two scenarios. Firstly, from symmetric distribution half of firms relocate to core region as single- plant exporters. Then they face agglomeration rant and are seduced to change their organization again to multi-plant. Secondly, all firms locate in core and transportation costs increase in some way, then some firms change their organization into multi-plant firms due to the deterioration of home market effect. Both of scenarios can be discussed in the same manner.

Again, the decision is evaluated by the nominal wage differential. Solving the nominal wage differential in (33) minus one for the critical value of transportation costs, we obtain an equation with Γ , m_1 , and $\frac{\mu}{\sigma}^6$. Evaluating the above equation with the two cases, all are multi-plant and all are single-plant. Then we obtain the following critical values.

⁵Under symmetric distribution case, when there are multi-plant firms, entrepreneurs engaging in these firms are assumed to be equally distributed between two regions. On the other hand, under core-periphery structure case, there are no incentives for entrepreneurs to stay in the periphery region. Thus we interpret the presence of multi-plant firms under core-periphery structure means that all of them stay in the core region but a part of them serve to the other region.

⁶Since this equation is too long to put in a paper, details are available upon request.

$$\overline{\phi^{MCP}} = 1 - \frac{2\left(1+\alpha\right)^2}{\left(1+\alpha\right)^2 - \frac{\mu}{\sigma}} \left(1 - \frac{1+\delta}{1+\alpha}\right)$$
(35)

$$\underline{\phi^{MCP}} = 1 - \frac{2(1+\delta)(1+\alpha)}{(2(1+\alpha) - (1+\delta))(1+\delta) - \frac{\mu}{\sigma}} \left(1 - \frac{1+\delta}{1+\alpha}\right)$$
(36)

Contrast to the symmetric distribution case, under core-periphery structure, we could observe mixed patterns of organization between these values. Since there is an advantage of home market effect, firms are not urged to change their organization. However, decreasing transport costs makes the home market effect larger and set the share of multi-plant firms attenuated. Under the value of lower critical value, ϕ^{MCP} , all firms choose to locate coreregion and be single-plant exporter. Above discussions could be summarized by the following proposition.

Proposition 2 Under core-periphery structure, there are mixed equilibrium of organization.

4 Conclusion

The assumption on the solitariness of firms' organization has an essential lack of understanding on activities of multi-national firms. The globalization and the development of new technologies can be characterized by lower transport costs of products and lower transaction costs in exporting as well as horizontal FDI. Besides the analysis on agglomeration economies of firms and workers, we explicitly introduce the organization choice to examine these two effects on choice of firms. We show that the decrease in transport costs induces firms agglomerate in one region, and also promotes firms to agglomerate their production in a single-plant firm. Furthermore, decrease in additional fixed costs would facilitate the development of multi-plant firms. The impact of globalization seems to be unambiguous and relatively relies on the differential of cost function between single- and multi- firm.

From our analysis, some results are emphasized. First, under symmetric regions, firms change their organization at one time and mixed organization of multi- and single- plant firms never occurs. This is because the presence of symmetric competing regions offsets the effects of changing organization. Secondly, the difference between the establishment fixed costs and the export fixed costs determine the stability of multi-plant organization, horizontal FDI. When establishment costs becomes lower, more firms choose multi-plant. On the other hand, when fixed export costs decrease, more firms choose single-exporting. We could confirm that transaction costs unambiguously affects not only the location choice of firms but also affects their organization choice. Thirdly, under core-periphery structure, we show that there is a range of transportation costs where there is mixed organization and that the cost differential between two organization and home market effect exhibit the proximity-concentration trade off in a different manner from the situation under symmetric distribution. Moreover, from some simulation results, we could observe multiple equilibria on organization under core-periphery structure. More detailed analysis would show some more interesting possibilities.

There would be other formulation on the differences of transaction costs in different organization. In particular, in our model, the role of establishment costs needs managers or entrepreneurs. They are assumed to consume in one region where is their residency, or say the place of headquarter. However, in the process of establishment of multi-plants, many managers are sent to the region and sometimes they spend more than ten years. It might be one way to change the assumption on the location of consumption. We try to capture the structure and the complicated decision of multi-plant firms. This is a modest attempt to capture the multinational entrepreneurs.

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Appendix I

Using four equations, (5), (12), and the corresponding equations for the other region, we obtain W_A^S, W_B^S, Y_A, Y_B explicitly.

$$\begin{split} W_1^S &= \frac{\mu}{\sigma} \left[\frac{Y_1}{\Delta} + \frac{Y_2}{\Delta^*} \phi \right] \\ W_2^S &= \frac{\mu}{\sigma} \left[\frac{Y_1}{\Delta} \phi + \frac{Y_2}{\Delta^*} \right] \\ Y_1 &= \frac{L}{2} + \lambda W_1^S \\ Y_2 &= \frac{L}{2} + (1 - \lambda) W_2^S \\ \end{split}$$

where $\Delta &= \left[\lambda + (1 - \lambda) \phi \right], \ \Delta^* = \left[\lambda \phi + (1 - \lambda) \right] \end{split}$

This yields a unique solution with

$$Y_{1} = \frac{\sigma L}{2(\sigma-\mu)} \frac{((1-\lambda)(\sigma-\mu)+\phi\lambda(\sigma+\mu))(\lambda+\phi(1-\lambda))}{\Phi_{S}}$$

$$Y_{2} = \frac{\sigma L}{2(\sigma-\mu)} \frac{(\lambda(\sigma-\mu)+\phi(1-\lambda)(\sigma+\mu))((1-\lambda)+\lambda\phi)}{\Phi_{S}}$$

$$W_{1}^{S} = \frac{L\mu}{2(\sigma-\mu)H} \frac{2\lambda\phi\sigma+(1-\lambda)(\sigma-\mu)+(1-\lambda)\phi^{2}(\sigma+\mu)}{\Phi_{S}}$$

$$W_{2}^{S} = \frac{L\mu}{2(\sigma-\mu)H} \frac{2(1-\lambda)\phi\sigma+\lambda(\sigma-\mu)+\phi^{2}\lambda(\sigma+\mu)}{\Phi_{S}}$$
where $\Phi_{S} = \left(\phi\sigma\left(\lambda^{2}+(1-\lambda)^{2}\right)+(1-\lambda)\lambda\left((\sigma-\mu)+\phi^{2}(\sigma+\mu)\right)\right)$

Appendix II

We set the share of single-plant firms and that of multi-plant firms as $(1 - m_r)$ and m_r , r = 1, 2 and put $\kappa \equiv \frac{\sigma(1+\delta)}{\mu N}, \Gamma \equiv \frac{(1+\delta)}{(1+\alpha)}$. Note that, for simpler notation, we set the share of firms in each region as λ in region 1, Λ in region 2, where $\lambda + \Lambda = 1$.

$$\begin{split} W_1^S &= \frac{1}{\kappa} \begin{bmatrix} Y_1 \\ \overline{\Delta} + \frac{Y_2}{\blacktriangle} \phi \end{bmatrix} \\ W_2^S &= \frac{1}{\kappa} \begin{bmatrix} Y_1 \\ \overline{\Delta} \phi + \frac{Y_2}{\bigstar} \end{bmatrix} \\ W^M &= \frac{\Gamma}{\kappa} \begin{bmatrix} Y_1 \\ \overline{\Delta} + \frac{Y_2}{\bigstar} \end{bmatrix} \\ Y_1 &= \frac{L}{2} + \lambda \left(1 - m_1 \right) W_1^S + \lambda m_1 W^M \\ Y_2 &= \frac{L}{2} + \Lambda \left(1 - m_2 \right) W_2^S + \Lambda m_2 W^M \\ \end{split}$$

where $\Delta &= \lambda \left(1 - m_1 \right) + \Lambda \left(1 - m_2 \right) \phi + \lambda m_1 + \Lambda m_2,$
 $\blacktriangle &= \lambda \left(1 - m_1 \right) \phi + \Lambda \left(1 - m_2 \right) + \lambda m_1 + \Lambda m_2$

Since there are five unknown variables with five equations, we obtain a unique solution. Wages for each firms are as follows

$$\begin{split} W_1^S &= \frac{L}{2} \frac{\kappa(\mathbf{A} + \phi \Delta) + \Gamma(1 - \phi)(\lambda m_1 - \Lambda m_2) - \Lambda(1 - \phi)(\phi + 1)(1 - m_2)}{\kappa^2 \mathbf{A} \Delta + \Gamma \Lambda \lambda(m_1(1 - m_2) + m_2(1 - m_1))(1 - \phi) + \Lambda \lambda(1 - \phi)(1 + \phi)(1 - m_2)(1 - m_1) - \kappa \Delta(1 - m_2 + \Gamma m_2) \Lambda - \kappa \mathbf{A}(1 - m_1 + \Gamma m_1) \lambda} \\ W_2^S &= \frac{L}{2} \frac{\kappa(\Delta + \phi \mathbf{A}) + \Gamma(1 - \phi)(\Lambda m_2 - \lambda m_1) - \lambda(1 - \phi)(1 + \phi)(1 - m_1)}{\kappa^2 \mathbf{A} \Delta + \Gamma \Lambda \lambda(m_1(1 - m_2) + m_2(1 - m_1))(1 - \phi) + \Lambda \lambda(1 - \phi)(1 + \phi)(1 - m_2)(1 - m_1) - \kappa \Delta(1 - m_2 + \Gamma m_2) \Lambda - \kappa \mathbf{A}(1 - m_1 + \Gamma m_1) \lambda} \\ W^M &= \frac{\Gamma L}{2} \frac{\kappa(\mathbf{A} + \Delta) - \lambda(1 - m_1)(1 - \phi) - \Lambda(1 - m_2)(1 - m_1) - \kappa \Delta(1 - m_2 + \Gamma m_2) \Lambda - \kappa \mathbf{A}(1 - m_1 + \Gamma m_1) \lambda}{\kappa^2 \mathbf{A} \Delta + \Gamma \Lambda \lambda(m_1(1 - m_2) + m_2(1 - m_1))(1 - \phi) + \Lambda \lambda(1 - \phi)(1 + \phi)(1 - m_2)(1 - m_1) - \kappa \Delta(1 - m_2 + \Gamma m_2) \Lambda - \kappa \mathbf{A}(1 - m_1 + \Gamma m_1) \lambda} \end{split}$$

Using these results, we obtain (26) to (28). Furthermore, after substituting κ , with the total number of firms, N, into the nominal wage differentials in the text, differentiating them with respect to the share of multi-plant firms in each region, m_1 and m_2 , and evaluating with the point that all firms are multi-plant firms, $m_1 = m_2 = 1$, we could find the following results. Note that $\frac{(1+\phi)(1+\delta)}{(1+\alpha)} < 2$ and $\sigma > 1$ always hold.

$$\frac{d}{dm_1} \frac{W_1^S}{W^M} \Big|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1} = \frac{(1-\phi)}{8\sigma} \left(\frac{\mu}{(1+\delta)(1+\alpha)} \left(2 - \frac{(1+\phi)}{\sigma} \frac{(1+\delta)}{(1+\alpha)} \right) + (1-\phi) \frac{(1+\delta)}{(1+\alpha)} \right) > 0$$

$$\frac{d}{dm_2} \frac{W_1^S}{W^M} \Big|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1} = -\frac{(1-\phi)}{8\sigma} \left(\frac{\mu}{(1+\delta)(1+\alpha)} \left(2 - \frac{(1+\phi)}{\sigma} \frac{(1+\delta)}{(1+\alpha)} \right) + (1-\phi) \frac{(1+\delta)}{(1+\alpha)} \right) < 0$$

$$\frac{d}{dm_1} \frac{W_2^S}{W^M} \Big|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1} = -\frac{(1-\phi)}{8\sigma} \left(\frac{\mu}{(1+\delta)(1+\alpha)} \left(2 - \frac{(1+\phi)}{\sigma} \frac{(1+\delta)}{(1+\alpha)} \right) + (1-\phi) \frac{(1+\delta)}{(1+\alpha)} \right) < 0$$

$$\frac{d}{dm_2} \frac{W_2^S}{W^M} \Big|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1} = \frac{(1-\phi)}{8\sigma} \left(\frac{\mu}{(1+\delta)(1+\alpha)} \left(2 - \frac{(1+\phi)}{\sigma} \frac{(1+\delta)}{(1+\alpha)} \right) + (1-\phi) \frac{(1+\delta)}{(1+\alpha)} \right) > 0$$

$$\frac{d}{dm_1} \frac{W_1^S}{W^M} \Big|_{\lambda = 1, m_1 = 1, m_2 = 0} - \frac{d}{dm_2} \frac{W_2^S}{W^M} \Big|_{\lambda = \frac{1}{2}, m_1 = m_2 = 1} = \frac{(1-\phi)(\sigma-1)}{8\sigma^2(1+\alpha)^2} \left((1-\phi) \left(\sigma + \mu + \alpha\sigma + \sigma\delta + \alpha\sigma\delta \right) - 2\mu \right)$$