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Intra-National Regional Heterogeneity in International Trade: Foreign Growth on Exports and Production of Domestic Regions

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Abstract

International trade can induce changes in production structure across domestic regions as well as across industries. While the literature is well established on the latter issue, the former issue has been examined less. We present a two-country model with explicit incorporation of two regions in a home country and one region in a foreign country. Skilled workers, freely mobile across domestic regions, are required to set up a firm, and one region is located closer to a foreign country. Our theoretical model suggests that effects of foreign growth on production are asymmetric among regions while causing positive effects on the exports of all regions. We empirically test our theoretical hypothesis with production and export datasets of Japanese regions. Our empirical results provide strong evidence in support of a positive growth effect of a foreign market on regional exports and capture asymmetric effects of foreign growth on the production of domestic regions.

Keywords: Full information maximum likelihood; International trade; Regional exports; Regional heterogeneity; Regional production.

JEL Classification Codes: F12; F14; R12

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1. Introduction

It is well recognized in economics that trade liberalization causes changes in the industry structure of domestic production. By allowing international trade into an autarky economy in a classical Hecksher-Ohlin model, a country shifts its production to an industry that utilizes relatively more of the country's abundant resources. Numerous theoretical models and empirical studies have examined this issue. However, less attention is paid to the fact that international trade also induces a change in the geographical structure of domestic production.

For example, production in border states or regions grows more than other regions due to their geographical access to foreign markets. Maquiladoras in the border states in Mexico may be a special case because of incentives in preferential tariff arrangements. However, the number of maquiladora firms in the border states continued increasing even after completion of the NAFTA agreement. Faced with the expansion of international trade, it is advantageous for new entrants to set up manufacturing plants in the regions closer to foreign markets, even without preferential tariff treatments.

Other important examples are Eastern European countries after acceptance into the EU as new member countries. The important external market for home industries in Eastern European countries was either non-existent or was located on their eastern side before the collapse of the former Soviet Union in 1991. A new challenge and opportunity emerged on their western borders during the transition period. Utilizing annual census-type data of Hungarian firms, Szanyi et al. (2010) examined the industry clusters (agglomeration) among 20 comitats (provinces) and found that the automotive sector is highly concentrated in two northwestern border comitats, whereas the processed food sector forms industry clusters in four eastern border comitats.

Two economic forces underlie the examples highlighted above. Faced with an export opportunity, home firms must decide on how much to produce/export (market effect) and where to produce (relocation effect)[1]. On one hand, the market effect, due to trade liberalization or the rapid expansion of a foreign economy, generates positive spillovers to all home regions. On the other hand, the relocation effect imposes asymmetric effects on home regions. For the border states in Mexico and border comitats in Hungary, we observed that the foreign economy imposes a positive market effect and a positive relocation effect. We should note, however, a negative relocation

[1] Alternative places to produce should include foreign countries, i.e., foreign direct investment (FDI). However, we focus on only home regions in this paper. Empirical evidence on the determinants of FDI is discussed in Cheng and Kwan (2000) for inward FDI in China.

effect is observed on non-border states.

As a negative side effect of the concentration of industries in border states, Hanson (1998) documents that manufacturing production in non-border regions of Mexico experienced downturns. The share of manufacturing employment in Mexico City dropped from 36.8 percent in 1985 to 23 percent in 1998, according to Jordaan (2008). This phenomenon can be explained by the many maquiladora firms moving to border states from Mexico City. Thus, trade liberalization enforces asymmetric effects on the production of domestic regions and therefore leads to a drastic change in the geographical structure of industries.

Although relocation affects certain home regions negatively, the net effect of market and relocation at the national level is expected to be positive. On the contrary, as a new, fierce source of competition, the rapid growth of foreign firms put downward pressure on the production of home firms in all regions. This applies to the case of Asian economies facing China as their trade partner in the region. The gross domestic product of China jumped from 1,934 billion RMB in 1990 to 11,390 billion RMB in 2008[2]. During this period, China's share of world GDP increased from 3.55 percent to 11.41 percent. While some developing countries benefited from China's growing demand, other countries faced a loss of export markets to Chinese goods (Jenkins, 2008). Focusing on the similarity of export products of developing countries to China's, Jenkins (2008), among other studies, finds that the ratio of products potentially under severe competition with China is high, even for Latin American countries but without mentioning Asian countries.

To address changes in the geographical structure of production, we particularly focus in this paper on three effects (the market effect, relocation effect, and competition effect) of the growth of foreign countries. In this paper, we regard international trade and the geographical structure of production as simultaneous outcomes, determined by the behaviors of exporters.

Given the backdrop of asymmetric effects of external factors on domestic regions, we explicitly introduce multi-regions in our theoretical model. Specifically, we present a trade model in which two heterogeneous regions within a country face region-specific international trade costs. Because we add extra complexity by introducing asymmetry among home regions, we simplify the foreign side by only considering one region in a foreign country.

Constructing a model with multiple regions within a country in the context of

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[2] At the constant current price in the World Economic Outlook database, International Monetary Fund, June 2010.

international trade theory is not new. In theoretical studies, Krugman and Elizondo (1996), Takahashi (2003), and Behrens et al. (2006, 2007) constructed models with multiple regions within a country. However, these studies focus on the effects of reduction in trade barriers on domestic agglomeration (dispersion) of industries, but not much on the patterns of international trade at the regional level[3]. On the contrary, this paper examines the effect of the growth of a foreign economy on regional exports and production.

We show that regional production tend to have heterogeneous responses with respect to the size of foreign economies. A part of this heterogeneity arises from relocation of firms within a home country that respond to an increase in the size of foreign economies. Some amount of agglomeration is at work in our model to make exporters relocate closer to foreign markets.By accounting for this effect on regional production, we show that the exports of all regions increase with the growth of foreign economies.

We empirically test our theoretical hypothesis against export and production datasets from Japanese regions[4]. The Japan Customs of Ministry of Finance provides export data at Harmonized System (HS) 9-digit level for each seaport/airport. We aggregated export data to 9 regions and to 18 industries. Explanatory variables (production by industry, distance from partner countries, employment) are also aggregated to 9 regions by 18 industries.

Our theoretical model suggests that at equilibrium both production and exports of home regions are determined simultaneously. We estimate export and production equations as a system of simultaneous equations by the maximum likelihood method. Our empirical results provide strong evidence of a positive growth effect of foreign markets on regional exports. At the same time, we find evidence that the growth of a foreign country as a rising new competitor puts downward pressure on regional production. Unlike previous single gravity-type equations, we are able to capture the simultaneous effects of foreign growth on both exports and production. Moreover, our estimates also find that the positive market effect exceeds the negative competitive effect for regions closer to foreign countries and vice versa for regions further away. More importantly, our model is capable of capturing the foreign growth effect that

[3] We should note that regional exports degenerate to national exports when a model produces a complete agglomeration of firms in one region at the equilibrium.

[4] The border-effect studies begun by the seminal work of McCallum (1995), using international trade at the city level in the US and Canada, are a precedent to this paper. Also, the study of Yilmazkuday (2012), using inter-state trade within the U.S., has a close relationship to our study.

asymmetrically affects home regions.

The structure of the rest of the paper is as follows. The next section introduces a two-country international trade model with explicit incorporation of two regions in the home country. We then derive a regional export function for given skilled workers in each region. In section 3, we utilize numerical methods to solve for the long-run equilibrium at which skilled workers move across regions. Section 4 empirically examines predictions of the theoretical model with applications to Japanese regional export data. We find strong support for the effect of foreign economic growth on exports and production in home regions. The last section discusses the results and conclusions.

2. The model

In this paper, we present a trade model in which two regions exist within a country, with heterogeneity introduced by region-specific international trade costs. Because we add extra complexity by introducing asymmetry among home regions, we simplify the foreign side by only considering one region in the foreign country. As such, our model can be considered as an extended model of Krugman and Elizondo (1996)[5] and Takahashi (2003). In addition to introducing heterogeneous international trade costs, our study differs from Krugman and Elizondo (1996) in that we investigate regional exports, whereas Krugman and Elizondo (1996) focus on the analysis of complete agglomeration of economic activities.[6] Our model differs from Takahashi (2003) in the assumptions of market structures. Our model assumes monopolistic competition markets for differentiated products in three regions, while Takahashi (2003) assumes two home regions produce homogeneous products.[7]

Exogenously, home regions only differ in terms of international trade costs in this paper. Due to this asymmetry in international trade costs, the price index of differentiated goods are region-specific and mobile workers migrate to the region in which they can earn higher real wage, resulting in another asymmetry in the share of skilled workers among home regions.

Behrens et al. (2009) also have a common theoretical background in which they constructed a model with more than two countries. The difference between their model and ours is the introduction of mobility of workers. In Behrens et al. (2009)'s

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[5] Krugman and Elizondo (1996) show that *symmetric* reduction in international trade costs make production in a single agglomerated region spread to both domestic regions.

[6] A series of studies by Behrens et al. (2006, 2007) that use a model with four regions also focused on the agglomeration of economic activities.

[7] The objective of Takahashi (2003) is the investigation of inefficient agglomeration in home regions when regions differ in geographical advantage and production efficiency.

multi-country world, workers cannot move between countries. However, we assumed that skilled worker can move between regions in the home country. In summary, our contribution in this paper is to investigate exports of domestic regions when the market of a foreign country affects the migration behavior of workers between regions in the home country.

The basic framework of our model is similar to the model of Krugman and Livas Elizondo (1996)[8]. The economy consists of two countries, home, *H*, and foreign, *F*. The home country has two regions, 1 and 2, while the foreign country has only one region[9]. The two countries are assumed to be able to access the same technology, so a Ricardian productivity difference between countries does not induce trade in this model.

Two types of workers live in both countries: skilled and unskilled workers. The numbers of skilled and unskilled workers in the home (foreign) country are denoted as L_H (L_F) and A_H (A_F), respectively. Individuals work and consume in the region in which they live. Skilled workers can move freely between regions but not between countries, while unskilled workers are assumed to be immobile. We assume for simplicity that unskilled workers in the home country are evenly distributed between the two regions, i.e., $A_1 = A_2$. The share of skilled workers in region 1 in *H* is denoted by $\lambda \in [0,1]$. Therefore, $L_1 = \lambda L_H$ and $L_2 = (1-\lambda) L_H$.

Workers consume two types of goods: homogeneous goods and differentiated goods. The individual utility function is assumed to take the following form:

$$U = A^{1-\alpha} M^{\alpha}, \tag{1}$$

where A is the consumption for homogeneous goods, M refers to the sub-utility function with regard to the consumption of differentiated goods, and α is the share of expenditure devoted to differentiated goods. Specifically, the consumption of variety m_i enters sub-utility as the following:

$$M = \left[\int_0^N m_i^{1/(1-\sigma)} di\right]^{1-\sigma}, \tag{2}$$

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[8] Our model is different from the model of Krugman and Livas Elizondo (1996) in three ways. First, there are no commuting costs within one region in our model. This means that there is no congestion in a region. Second, there are two types of workers in our model. Third, we introduce asymmetric international trade costs between two home regions.

[9] Hereafter, we use country *F* and region *F* interchangeably.

where N is the number of varieties in the world economy (including both home and foreign) and $\sigma(>1)$ is the elasticity of substitution among varieties.

By solving the utility maximization problem with a budget constraint, the indirect utility function is derived as follows:

$$V_r^i = \alpha^{\alpha}(1-\alpha)^{1-\alpha}\frac{w_r^{\;i}}{(P_r)^{\alpha}}\,, \qquad (3)$$

where $V_r^{\;i}$ represents the indirect utility of a worker of type i (skilled, unskilled) and residency in region r (*1*, *2* and *F*), with $w_r^{\;i}$ as the wage rate of worker type i in region r. In addition, P_r is price index in region r and given by

$$P_r \equiv \int_0^{n_1}\left(p_{1r}(v)\right)^{1-\sigma}dv + \int_0^{n_2}\left(p_{2r}(v)\right)^{1-\sigma}dv + \int_0^{n_F}\left(p_{Fr}(v)\right)^{1-\sigma}dv\,, \qquad (4)$$

where n_r (r=*1*, *2* and *F*) is the number of varieties produced in region r and $p_{sr}(v)$ (s, r=1, 2, and F) is the price of a variety, indexed by v, that is produced in region s and consumed in region r.

Turning to trade costs of differentiated goods, both international and intra-national trades incur costs.[10] However, intra-regional trade is costless. Transportation costs are assumed to be iceberg-type. When one unit of a variety is sent from region s to region r, $1/\tau_{sr}$ units of this variety arrives in region r, where τ_{sr} is greater than 1. In other words, transportation costs decrease as τ_{sr} decreases. Because of these transportation costs, the consumer prices of a variety are set differently among regions:

$$p_{sr}(v) = \tau_{sr}\, p_s(v)\,, \qquad (5)$$

where $p_s(v)$ is the producer price of variety v in region s. Note that τ_{ss} is 1 because intra-regional trade is assumed costless.

The most important features in our model are generated by a simple and plausible assumption that international transportation costs are region-specific[11]. More

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10 If we assume that trade costs increases monotonically with distance, geographical distance can be used as a proxy for trade costs in the later analysis.

11 The importance and difficulty of measuring trade costs are fully discussed in

precisely, international transportation costs between regions 1 and *F* are not the same as between regions 2 and *F*, namely, $\tau_{1F} \neq \tau_{2F}$. While international transportation costs are asymmetric between home regions, those costs are supposed to be symmetric for any pair of two regions.[12] In other words, we assume that $\tau_{rF} = \tau_{Fr}$ $(r = 1.2)$. Moreover, region 1 is assumed to have the advantage of access to country *F*. That is, we assume that $\tau_{1F} < \tau_{2F}$.[13] In addition to international trade costs, the shipping of differentiated goods between regions in *H* is assumed to incur τ_{12}.[14]

It is also important to note the relative magnitude of transportation costs. We suppose that domestic transportation costs are smaller than international transportation costs. Furthermore, we impose another restriction to exclude the case in which exports from region 2 to country *F* via region 1 do not occur. In short, the assumptions of the magnitude of transportation costs are described by $\tau_{12} < \tau_{1F} < \tau_{2F}$ and $\tau_{2F} < \tau_{1F} + \tau_{12}$.[15]

On the supply side, there are two sectors in the economy. One sector produces the homogeneous goods under perfect competition, using unskilled labor as the only input, with constant returns to scale technology. We choose homogeneous goods as a numeraire. The unit input requirement is set to one. The shipping of homogeneous goods is assumed to be costless. From this assumption and our normalization, the wage of unskilled labor is equal to one in all regions in equilibrium. For the sake of simpler presentation, we use w_r to denote the wage of skilled labor in region *r*.

The differentiated goods sector consists of monopolistically competitive firms producing a continuum of varieties of the horizontally differentiated goods. We assume that the firms can differentiate their products at no cost. Each firm, therefore, produces only one variety, which leads the number of firms to become equal to the number of

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Anderson and van Wincoop (2004). All of the followings constitute trade costs: tariffs, quotas, transportation, insurance, and time costs. Because our focus is on the difference among regions within a country, the most of constituents in trade costs are common among regions. In this paper, we use the term “transportation cost” as a differentiated part of overall trade costs.

12 Waugh (2010) argues the trade frictions between rich and poor countries are systematically asymmetric.

13 Figure 1 depicts our assumptions regarding the geography of regions in this paper.

14 As will be clear, this non-zero inter-regional transportation cost makes the location of production a relevant decision for home firms. Otherwise, a home exporter incurs the same transportation cost regardless of where she produces. See also the next footnote.

15 The latter restriction is unnecessary in this model because there is no mechanism by which region 2 uses region 1 as an export-platform. By imposing this restriction, however, there will be only direct export even if an export-platform mechanism is explicitly introduced in the model.

varieties in the world. Each firm incurs $f(>0)$ units of skilled labor as a fixed cost, and $\beta(>0)$ units of unskilled labor as its marginal labor requirement. Under this technology, the prices of differentiated goods produced in any region are $p(v)=\sigma\beta/(\sigma-1)$. Because the price does not depend on the type of variety, we denote $p(v)$ simply as p. The firms are assumed to be able to enter and exit freely, which results in zero profit for the firms. The zero profit condition drives the size of the firms. The profit of each firm is given by $\pi_r = px_r - (fw_r + \beta x_r)$, where x_r is the amount of output of the firm in region *r*. From the zero profit condition, the output is found to be $x_r = (\sigma-1) fw_r / \beta$. It is worth noting that the size of the firm increases with the wage of skilled workers.

Because the price of each variety does not depend on region, the price index of region *r* is rewritten by

$$P_r = p\left(n_1 T_{1r} + n_2 T_{2r} + n_F T_{Fr}\right)^{\frac{1}{1-\sigma}}, \text{ where } T_{sr} \equiv \tau_{sr}^{1-\sigma}. \tag{6}$$

Note that $T_{sr} \in [0,1)$. Here, the value of 0 for T_{sr} would produce infinite transportation costs, while the value of 1 produces no transportation costs.

As firms employ different techniques to produce differentiated goods, the numbers of firms in each region n_r (*r* = 1, 2, and F) is determined by the market-clearing condition for skilled labor in each region as follows:

$$n_1 = \frac{\lambda L_H}{f}, \quad n_2 = \frac{(1-\lambda) L_H}{f}, \text{and } n_F = \frac{L_F}{f}. \tag{7}$$

Differentiated goods-market clearing conditions enable us to find the wage functions of each region:

$$w_r = \frac{\alpha}{\sigma}\left(\frac{T_{1r}Y_1}{G_1} + \frac{T_{2r}Y_2}{G_2} + \frac{T_{Fr}Y_F}{G_F}\right), \qquad (r=1, 2 \text{ and } F) \tag{8}$$

where Y_r is the aggregate regional income in region *r* and is defined as $Y_r \equiv A_r + w_r L_r$, and $G_r \equiv L_1 T_{1r} + L_2 T_{2r} + L_F T_{Fr}$. Solving a set of equations composed of the three wage functions shown above derives the wages in each region when the distribution of skilled workers in *H* is given.

Once the equilibrium share of skilled labor is found, the equilibrium values of the regional exports of each region in *H* are obtained. The value of the regional exports is the number of firms in the exporting region times the value of the regional demand including transportation costs from the importing country. When the values of regional exports of differentiated goods produced in each home region are denoted by E_1 and E_2, these export functions are represented as follows:

$$E_1 = n_1 pT_{1F} \frac{\alpha Y_F}{P_F^{\ 1-\sigma}}, \quad E_2 = n_2 pT_{2F} \frac{\alpha Y_F}{P_F^{\ 1-\sigma}} \tag{9}$$

By using the price index and the definition of the regional income, the equations in (9) are rewritten explicitly with model parameters as follows:

$$E_1 = \frac{\lambda L_H T_{1F} \alpha (A_F + w_F L_F)}{[\lambda T_{1F} + (1-\lambda)T_{2F}]L_H + L_F}, \quad E_2 = \frac{(1-\lambda) L_H T_{2F} \alpha (A_F + w_F L_F)}{[\lambda T_{1F} + (1-\lambda)T_{2F}]L_H + L_F}. \tag{10}$$

It is important to note that the regional exports depend on λ, the share of skilled workers in *H,* as well as other model parameters. With these export functions, we can analyze the effect of transportation costs and the size of the economy on international trade to derive a variant of a gravity model.[16] It is also appealing to our intuition that due to the model's CES structure when all transportation costs disappear, equation (10) simply becomes the share of region 1's skilled labor as a percentage of the world's skilled labor multiplied by the share of manufacturing products and foreign income, i.e., $T_{1F} = T_{2F} = 1$.

$$E_1 = \frac{\lambda L_H}{L_H + L_F} \alpha Y_F \tag{11}$$

Without resorting to a numerical analysis of comparative statistics of equilibrium regional exports, some distinctive features stand out in the structure of these export functions, and we will discuss these features thoroughly in turn.

First, only a subset of parameters appears explicitly in regional export functions. Some parameters regarding home regional characteristics do not *directly* affect regional exports, although all parameters in the model *indirectly* affect regional exports through λ. Because λ is the ratio of home skilled workers and therefore proportionate to the number of firms and then to production, we call the effect of parameters in the model on λ an indirect effect on production in the following discussion. It is important to note that all of these indirect effects on production are

[16] The theoretical foundation for the traditional gravity model with the effect of trade costs and income of two countries on bilateral trade is given in Anderson (1979).

asymmetric between the two regions[17].

Second, direct effects are unambiguous for some important variables. The direct effect of foreign income is positive on both regions' exports. Y_F enters positively in both regional export functions in equation (10). The income growth of foreign countries promotes exports of all regions in the home country. The production effects, which are λ for region 1 and $1-\lambda$ for region 2, are positive for both regional exports. The expansion of production in each region correlates with each region's exports. The direct effect of transportation costs can be shown to be negative, agreeing with the literature. A decrease in T_{1F}, indicating an increase in transportation costs, lowers regional export.

Third, larger numbers of unskilled workers in home regions should increase production but do not appear directly in regional export functions. Therefore, unskilled workers in home regions only indirectly affect regional exports via their effect on regional production.

Fourth, improvements by the foreign country such as, for example, a decline in fixed cost, *f*, will reduce the price index (6) of that foreign country. This will in turn decrease the value of exports of both home regions by equation (9). This effect can be considered to be a competition effect.

The distinction between direct and indirect effects on regional exports becomes very important when we later consider an empirical model in section 4. Our strategy of econometric methodology is to estimate regional production and export regression equations. Only variables directly affecting regional exports are included in the regional export equation, whereas variables that indirectly effect exports via regional productions are included in the regional production equations. We estimate these simultaneous equations by full information maximum likelihood estimation.

3. The equilibrium

The results obtained in the previous section are derived by treating the endogenous variable λ, the ratio of skilled worker in region 1, as predetermined. Given this ratio and given the number of skilled workers in both home regions, results in section 2 are at equilibrium. However, this ratio is endogenously determined by all

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[17] Home domestic transportation cost, T_{12}, and home regional unskilled labors, A_1 and A_2, do not appear explicitly in regional exports. For these parameters, the effect is only via indirect effects on production and the expected signs of effect are opposite between two regions due to the difference in the first part in the numerators, λ and $1-\lambda$, respectively, for region 1 export and region 2 export.

parameters in this model. In this section, we describe how λ is determined at equilibrium.

To complete the model, we have to find the distribution of skilled workers in *H*. Because skilled workers can move between the two regions in *H*, the utilities of skilled workers in region 1 have to be equal to that in region 2 at equilibrium. Therefore, the following relationship has to hold at equilibrium:

$$V_1(\lambda) = V_2(\lambda) \Rightarrow \frac{w_1(\lambda^*)}{(P_1(\lambda^*))^\alpha} = \frac{w_2(\lambda^*)}{(P_2(\lambda^*))^\alpha}, \qquad (12)$$

where λ^* represents the equilibrium share of skilled labor in region 1. By using this equilibrium condition and wage functions, the equilibrium share of the skilled workers in region 1 is obtained. With this λ^*, export functions (10) are at equilibrium.

3-1. Long-run equilibrium

The model in our paper is constructed to provide an analytical foundation to investigate regional exports within a country.[18] Namely, we restrict our equilibrium concept to stable situations in which all regions export. We restate all parameter restrictions imposed in this paper so far as the following assumptions before our formal definition of an equilibrium concept. All eleven parameters in this model are denoted by $\theta = (\alpha, \beta, \sigma, f, L_F, L_H, A_F, A_H, \tau_{1F}, \tau_{2F,} \tau_{12})$. We denote the difference in indirect utility of two regions as $\Delta V(\lambda) \equiv V_1(\lambda) - V_2(\lambda)$.

Assumptions:

(a1) All parameters are non-negative. (a2) $\tau_{12} < \tau_{1F} < \tau_{2F}$. (a3) $\tau_{2F} < \tau_{1F} + \tau_{12}$.

Definition (Long-run Stable Regional Export Equilibrium):

The set of parameters $\theta = (\alpha, \beta, \sigma, f, L_F, L_H, A_F, A_H, \tau_{1F}, \tau_{2F,} \tau_{12})$ satisfies assumptions (a1) through (a3), and λ^* is defined to be at a long-run stable regional export (**LSRE**) equilibrium if (i) λ^* is strictly within the range between 0 and 1, (ii) $\Delta V(\lambda^*) = 0$ (iii) $d\Delta V(\lambda^*) / d\lambda \leq 0$.

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18 For studies intended to provide theoretical explanations for regional agglomerations, equilibria at two extremes are interesting in themselves.

The first condition of the definition of λ^* implies that some skilled workers always remain in each home region, assuring that there will be production of differentiated products and export in each region. The second and third conditions require that the share of skilled workers is endogenously determined and stable. The random choice of numerical values for eleven parameters might not guarantee that condition (ii) holds for certain λ but not for the other two conditions.

Imposing the restriction that complete agglomeration (i.e., all firms are set up in only one region) cannot occur restricts the relative size of the two labor types.

3-2. An Equilibrium Example by Numerical Analysis

In this subsection, we show a LSRE equilibrium by using a numerical method. With parameter values given in appendix A-1, we obtain **LSRE** equilibrium in which the share of skilled workers in region 1 is approximately 0.566. It is important to note that the roughly 20 percent difference in transportation costs results in the 30 percent difference in the share of skilled workers. The effect of the difference in international transportation costs on regional exports is more pronounced: export values are approximately 16.0 for region 1 and approximately 9.8 for region 2. Specifically, the 20 percent difference in transportation costs leads to about a 63 percent difference in regional exports. We confirm the distance effect in a general gravity model still holds for our intra-national regional model.

4. Estimation Model for Regional Exports and Production

For directly applying export equations in theoretical sections for empirical exercise, we need to address three important issues: industry selection, proxy variables and endogeneity. Recall that regional export equations for differentiated product industries are derived in equation (10) as follows.

$$E_1 = \frac{\lambda L_H T_{1F} \alpha (A_F + w_F L_F)}{[\lambda T_{1F} + (1-\lambda) T_{2F}] L_H + L_F}.$$

Using $x_1 = (\sigma - 1) f w_1 / \beta$ and $n_1 = \lambda L_H / f$, the regional export function can also be shown as the following.

$$E_1 = \frac{n_1 x_1 \dfrac{\beta}{(\sigma-1)} \dfrac{1}{w_1} T_{1F} \alpha Y_F}{[\lambda T_{1F} + (1-\lambda) T_{2F}] L_H + L_F} \tag{13}$$

Export equations are functions of regional production, n_1x_1, the trade cost, T_{1F}, the expenditure share for differentiated products, α, the elasticity of substitution, σ, marginal labor requirement, β, the regional wage, w_1, foreign income, Y_F, and the weighted sum of skilled workers in the world, $[\lambda T_{1F} + (1-\lambda)T_{2F}]L_H + L_F$]. By taking the logarithm of the regional export equation and rearranging the terms, we obtain the following estimation model.

$$\begin{aligned} \ln E_{1j} &= \ln n_1 x_1 + \ln T_{1j} + \ln \alpha\beta/(\sigma-1) - \ln w_1 + \ln Y_j \\ &\quad - \ln\left\{[\lambda T_{1j} + (1-\lambda)T_{2j}]L_H + L_F\right\} \end{aligned} \qquad (14)$$

The first term in equation (14) is the regional production, denoted as *Pro*. When regional production data are available at the industry level, we denote production of industry *k* in region *i* by Pro_{ik}. By using the distance between the region and the importing country, *Dist*, as a proxy for transportation cost, denoting regional wage as *Wage*, and denoting the income of the importing country as *GDPIM*, we obtain the estimation equation (15). Note that export equations of all regions share the common denominator referred to in equation (10); therefore, it is a region-invariant variable. We proxy this denominator by importing both country dummies and industry dummies. The three parameters are also captured by two sets of dummies.

$$\begin{aligned} \ln E_{ijkt} &= \alpha_1 \ln Pro_{ikt} + \alpha_2 Dist_{ij} + \alpha_3 \ln Wage_{it} + \alpha_4 \ln GDPIM_{jt} \\ &\quad + \theta_j + \theta_k + \varepsilon_{ijkt} \end{aligned} \qquad (15)$$

where Pro_{ikt} is *k*-th industry production at Japanese region *i*, $Dist_{ij}$ is the distance between the Japanese region and the importer, $Wage_{it}$ is the wage in region *i*, $GDPIM_{jt}$ is gross domestic product of the importing country, θ_j and θ_k are importer dummies and industry dummies, respectively, and ε_{ijkt} is a disturbance term.

The most severe econometric problem of estimating the above single equation is that our theoretical model provides that the number of skilled workers in a region (or regional production) is endogenously determined by the number of regional unskilled workers and foreign demand. Estimating the export equation without addressing endogeneity of the production variable leads to the well-known inconsistency in estimates of all variables. Therefore, we proceed to add a regional production equation and estimate system of equations by full information maximum likelihood.

$$\ln Pro_{ikt} = \beta_1 D\_Dist_{ij} \times \ln GDPIM_{jt} + \beta_2 \ln POP_{it} + \theta_j^{'} + \theta_k^{'} + v_{ijkt} \qquad (16)$$

where D_Dist_{ij} is the distance indicator variable, $GDPIM_{jt}$ is gross domestic product of the importing country, POP_{it} is the population of region, $\theta_j^{'}$ and $\theta_k^{'}$ are importer dummies and industry dummies, respectively, and v_{ijkt} is a disturbance term. Our model suggests that distance does not symmetrically influence regional production; a region with a geographical advantage attracts more firms from other regions when foreign markets grow large. We constructed an indicator variable, D_Dist_{ij}, that takes on a positive value when a region is located closer than average to a foreign market and a negative value when farther than average away. D_Dist_{ij} is defined as log of average distance (between importer *j* and regions) over distance (between importer *j* and region *i*).

5. An Application to Japanese Exports

In previous sections, we provided a concrete theoretical international trade model that can account for the effects on geographical structure of industry production within a country, and we have suggested full information maximum likelihood estimation method for simultaneous equations of export and production functions. However, the data requirement for this study is much more demanding than standard empirical works in international trade. Export and production data at a finer disaggregation than country level are needed, but few countries readily make such data publicly available. Fortunately, Japan provides both exports and production data that match with the requirements of this study[19].

International trade data are provided by the Japanese Customs of the Ministry of Finance at each international port. Most prefectures in Japan have multiple international ports. Production data are also available at prefecture level. As an example, figure 2 shows 2005 production data for industrial robot and medical equipment,

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19 As a closely related empirical work to our study, Davis and Weinstein (1999) investigated regional production in Japan and showed the home-market effect at the regional level works.

illustrating how the production of an industry can be sparsely distributed across the nation. This figure can provide the intuition that production is relatively dispersed across regions within a country; however, it falls short in telling us what exports from these regions may look like. We use port-level export data in this section to address the region-based hypotheses provided in the previous section.

5-1. Data

Production data at prefecture level are obtained from the *Prefecture Products by Economic Activity*, Cabinet Office, the government of Japan. These production data are based on the Japan SNA (System of National Accounts) industry classification. We selected 18 industries: agriculture, forestry, fisheries, mining, services and 13 manufacturing industries from this data set (see appendix A-4). The annual data at this level of disaggregation over domestic regions are only available from 1990; our sample period, therefore, starts in 1990 and ends at 2006.

Export data are taken from the database of the Japanese Customs of the Ministry of Finance. The Japanese Customs provides finely disaggregated export data for each international port/airport[20]. The original annual export series is provided at a Harmonized System (HS) 9-digit level and by each destination country. Our aggregation process takes three steps. First, HS 9-digit commodities are aggregated over HS 2-digit industries.[21] Second, we aggregated these port-level exports at the HS 2-digit level for each prefecture. Industries are defined by two different classification systems. We compared HS 2-digit industry against SNA industry and with detailed definitions for each classification system, creating a correspondence table between the two systems (see Appendix A-5). As the third step, export data at HS 2-digit industry level are aggregated to 18 SNA industries according to the correspondence table.

At this point, we decided to further aggregate these prefecture exports for two reasons. Some prefectures do not report any exports due to a lack of international ports in the prefectures. Firms in these prefectures export from ports in another prefecture. Similarly, there must exist some firms, especially near prefecture borders, that use international ports in adjacent prefectures. To minimize the effect of cross-border export on our estimates, we grouped 47 prefectures into nine regions. In the third step, we

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[20] As a study using port level data, Blonigen and Wilson (2008) measure the efficiency of US and foreign ports and find that improved port efficiency significantly increases trade volumes. The aggregation of ports in this study mitigates possible difference in port efficiency among regions. The most efficient Japanese ports, measured by Blonigen and Wilson (2008), are relatively dispersed geographically.

[21] Descriptions for these HS 2-digit industries are provided in Appendix A-2.

constructed the export series at the SNA industry level for these nine regions in Japan. The details of these regions are given in Appendix A-3. Eight destination countries were selected: China, Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand.

Regional employment data are taken from the Census in Japan. GDP and employment data for nine Asian countries are taken from the World Development Indicators of the World Bank. The original GDP series in US dollars is converted to Japanese yen values by period-average foreign exchange rates. All series are adjusted to be expressed in terms of Japanese yen. Regional wage data are taken from the Ministry of Health, Labour, and Welfare. We selected male wage in the financial sector to best represent the wage of skilled workers in our model[22].

The distances between the Japanese regions and other Asian countries are measured in two steps. First, the distance to each Asian country is measured from each prefecture. When there are more than two local ports in a prefecture, the port with the largest value of trade is chosen for the measurement. Then, the distance between an Asian country and a region is defined as the shortest distance between the country and the prefectures in the region.

Note that for all variables, to match geographical aggregation with export data, prefecture data are also aggregated to nine regions. The number of observations is 17,813[23].

5-2. Estimation Results

The result of full information maximum likelihood estimation is presented in Table 1. Regarding the four variables of interest in the export equation, all estimates are confirmatory to expected sign and are statistically significant. First, the estimated coefficient for income of importing country is 4.162 in specification (1) and significant at the one percent level, which implies that a one percent growth of income of a trade partner induces about four percent growth in export of each Japanese region. Second, the distance between each importing country and each Japanese region represses

[22] Other industries are the construction, manufacturing, retail and service sectors.

[23] The total number of observations is 22,032 because we have 17 years, 9 regions, 8 importers, and 18 industries. Because of log specification for exports, 4,219 observations with a zero value of exports are removed from the sample. About one-third (1,731) of these zero value exports belong to the ninth region that consists only of Okinawa prefecture. Okinawa prefecture is not a large economic region within Japan; however, Okinawa is chosen as one region because it is located far from other regions. Note also that, by industry, Mining has 795 zero value exports.

regional export. Because distance enters in the export equation in non-log form, the estimated coefficients need to be multiplied by the distance variable in terms of elasticity. The elasticity of distance on export, therefore, varies approximately from one percent to five percent. Third, regional industry production has more than one-to-one correspondence with regional industry exports. The estimated coefficient is 1.632 and is statistically significantly larger than unity. Fourth, higher wages of skilled workers in a region put downward pressure on regional exports, by 2.71 percent when wages increase by 10 percent.

Turning to production equation, the estimated coefficient of the interaction term between the distance indicator variable and importer's economy size is positive and statistically significant. Note that indicator variable takes negative values for regions located further than average from foreign markets. Therefore, the result indicates that the growth of a foreign market induces, on the one hand, greater production in regions closer to foreign countries and, on the other, reduces production in regions far from foreign markets. This is consistent with our theoretical model that incorporates production shift across regions and with empirical studies by Hanson (1998), Jordaan (2008), and Szanyi et al. (2010). In addition, the population variable, representing unskilled workers in the model, is positive and statistically significant at the one percent level.

As an alternative specification, we separated distance the indicator variable and the importers' income variable. The growth of the foreign economy can force two opposing effects on home regions in our model. The first effect of foreign growth is to provide a larger export market for home exporters. The second effect of foreign growth is to put downward pressure on domestic production through the emergence of competing foreign firms. This downward pressure on domestic production may occur as production shifts overseas. It is also well documented that manufacturing firms in developed countries shift production to emerging economies as foreign direct investment, although it is not incorporated in our theoretical model. The estimated coefficient of the importers' income is negative and statistically significant. Combined with the results of the export equation, our results indicate that the economic growth of a foreign country may reduce domestic production (through tougher international competition and a shift of production overseas) and expand exports (due to larger export markets).

Estimated coefficients of our interest in regional export equations are robust to estimation methodology and specifications of the production equation. Regarding the specification of the production equation, we estimated a distance variable and an importers' income variable in both the multiplicity form and separate form. In both specifications of the production equation, we confirmed a relocation effect of foreign demand increasing production in border regions and decreasing in non-border regions.

As a robustness check, we also estimated the regional export equation as a single equation by ordinary least squares. Surprisingly, most of the estimated coefficients are very similar to full information maximum likelihood estimates in both magnitude and statistical significance. The only significant difference appeared in the estimated coefficient of the production variable. This supports our use of simultaneous equation modeling to overcome potential the endogeneity problem for the production variable. The single equation estimate undervalues the impact of production, proportional to the number of firms and the number of skilled workers in our model, by approximately 20 percent.

6. Discussions and conclusions

To address changes in the geographical structure of production and exports simultaneously, we particularly focus on the market effect, relocation effect, and competition effect of the growth of foreign countries on home regions. We introduced a two-country trade model with explicit incorporation of two regions in the home country and one region in a foreign country. With this model, we are able to capture three effects of foreign growth on home regional exports and productions.

With geographically disaggregated Japanese trade data, we applied full information maximum likelihood estimation for simultaneous equations of regional exports and production functions, with 12 industries in nine Japanese regions and eight Asian countries. Our empirical results provide evidence in support of a positive growth effect of a foreign country on regional exports and capture asymmetric effects of foreign growth on the production of home regions.

There are several trade models that consider regions within a country in addition to Krugman and Elizondo (1996) and Behrens et al. (2006, 2007). These focus on agglomeration within a country. Rossi-Hansberg (2005) considers a continuum segmented line model on which countries are intervals. This approach is flexible enough to allow for various types of regional production patterns within a county. Marjit and Beladi (2009) also consider a Ricardian model with a continuum region within a country. However, international (or intra-national) trade in these models is only necessitated by specialization in one of two products, so its direct application to empirical excise is limited. Our model is also capable of making predictions regarding regional productions, regional export ratios, and export tendencies with industry characteristics, among other issues that may be open to further investigation.

We particularly note three effects of foreign growth on home regions. First, the market effect indicates that as the size of a market increases, the economic growth of a foreign economy provides an opportunity to expand production for plants in the home country. This increase in home production is directly associated with exports. Second, a competition effect shows that as a foreign economy grows, it rises as a competitor, putting downward pressure on the production of home plants. This reduction in production need not lead to a decrease in exports of home plants. The combination of the two effects on a home country when a foreign country's economy grows may be positive. Third, any expansion of production will not be realized equally among plants in the home country due to the difference in geographical proximity to foreign demand, as observed among states in Mexico after trade liberalization.

Beyond many case studies and empirical investigations examining international trade of the border states in Mexico, international trade of the border regions are considered essential in many countries for promoting the growth of nationwide international trade. For example, the Department of Foreign Affairs and International Trade, Canada, initiated the Export USA/New Exporters to Border States (NEBS) program at the Consulate General of Canada in Buffalo, New York, in 1984, in conjunction with the Government of Ontario. The NEBS attracted more than 20,000 companies throughout Canada, and 50 percent of those firms eventually started to export[24].

[24] See the Canadian Trade Commissioner Service (2010).

Appendix:

A-1. Parameters calibration

In this appendix, we find a set of parameter values to satisfy our equilibrium concept (LSRE) by the following calibration. First, we start by choosing numerical values for preference parameters α and σ. A larger value for α shifts individual consumption toward differentiated products. We set $\alpha = 0.5$ and $\sigma = 2$.

Second, we set numerical values for both types of labor: A_F, A_H, L_F, and L_H. We maintained that the sizes of unskilled labor pools in both countries are equal. To hold LSRE, we found that (i) the unskilled labor pool needs to be much larger than the skilled labor pool and (ii) the skilled labor pool in a foreign country must be relatively smaller than that of home country. We set L_F=4, L_H=8, and A_F=A_H=100. Unskilled labor is equally distributed between two home regions; A_1=A_2=50.

Third, we set the skilled labor requirement as fixed cost, *f*, equal to 0.5. It is important to remember that both countries share the same technology, so the change in this parameter has a similar effect to simultaneous changes in the skilled labor pool in both countries. With numerical examinations, we confirm that this parameter and the amount of skilled labor are closely related; therefore, $\beta = 0.5$.

Finally, we need to determine the appropriate values for transportation costs: τ_{12}, τ_{1F}, and τ_{2F}. These parameters need to satisfy two assumptions described by (a2) and (a3). We set τ_{1F} =2.0, τ_{2F} =2.5, and τ_{12} =1.25.

A-2. Descriptions of Chapters (Two-digit HS classification codes)

1 Live animals.
2 Meat and edible meat offal.
3 Fish & crustacean, mollusc & other aquatic invertebrate
4 Dairy prod; birds' eggs; natural honey; edible prod nes
5 Products of animal origin, nes or included.
6 Live tree & other plant; bulb, root; cut flowers etc
7 Edible vegetables and certain roots and tubers.
8 Edible fruit and nuts; peel of citrus fruit or melons.
9 Coffee, tea, mat•ad spi œs.
10 Cereals.
11 Prod mill indust; malt; starches; inulin; wheat gluten
12 oil seed, oleagi fruits; miscell grain, seed, fruit etc
13 Lac; gums, resins & other vegetable saps & extracts.
14 Vegetable plaiting materials; vegetable products nes
15 Animal/veg fats & oils & their cleavage products; etc
16 Prep of meat, fish or crustaceans, molluscs etc
17 Sugars and sugar confectionery.
18 Cocoa and cocoa preparations.
19 Prep of cereal, flour, starch/milk; pastrycooks' prod
20 Prep of vegetable, fruit, nuts or other parts of plants
21 Miscellaneous edible preparations.
22 Beverages, spirits and vinegar.
23 Residues & waste from the food indust; prepr ani fodder
24 Tobacco and manufactured tobacco substitutes.
25 Salt; sulphur; earth & ston; plastering mat; lime & cem
26 ores, slag and ash.
27 Mineral fuels, oils & product of their distillation; etc
28 Inorgn chem; compds of prec met, radioact elements etc
29 organic chemicals.
30 Pharmaceutical products.
31 Fertilizers.
32 Tanning/dyeing extract; tannins & derivs; pigm etc
33 Essential oils & resinoids; perf, cosmetic/toilet prep
34 Soap, organic surface-active agents, washing prep, etc
35 Albuminoidal subs; modified starches; glues; enzymes.
36 Explosives; pyrotechnic prod; matches; pyrop alloy; etc
37 Photographic or cinematographic goods.
38 Miscellaneous chemical products.
39 Plastics and articles thereof.
40 Rubber and articles thereof.
41 Raw hides and skins (other than furskins) and leather.
42 Articles of leather; saddlery/harness; travel goods etc
43 Furskins and artificial fur; manufactures thereof.
44 Wood and articles of wood; wood charcoal.
45 Cork and articles of cork.
46 Manufactures of straw, esparto/other plaiting mat; etc
47 Pulp of wood/of other fibrous cellulosic mat; waste etc
48 Paper & paperboard; art of paper pulp, paper/paperboard
49 Printed books, newspapers, pictures & other product etc
50 Silk.
51 Wool, fine/coarse animal hair, horsehair yarn & fabric
52 Cotton.
53 other vegetable textile fibres; paper yarn & woven fab
54 Man-made filaments.
55 Man-made staple fibres.
56 Wadding, felt & nonwoven; yarns; twine, cordage, etc
57 Carpets and other textile floor coverings.
58 Special woven fab; tufted tex fab; lace; tapestries etc
59 Impregnated, coated, cover/laminated textile fabric etc
60 Knitted or crocheted fabrics.
61 Art of apparel & clothing access, knitted or crocheted.
62 Art of apparel & clothing access, not knitted/crocheted
63 other made up textile articles; sets; worn clothing etc
64 Footwear, gaiters and the like; parts of such articles.
65 Headgear and parts thereof.
66 Umbrellas, walking-sticks, seat-sticks, whips, etc
67 Prepr feathers & down; arti flower; articles human hair
68 Art of stone, plaster, cement, asbestos, mica/sim mat
69 Ceramic products.
70 Glass and glassware.
71 Natural/cultured pearls, prec stones & metals, coin etc
72 Iron and steel.
73 Articles of iron or steel.
74 Copper and articles thereof.
75 Nickel and articles thereof.
76 Aluminium and articles thereof.
78 Lead and articles thereof.
79 Zinc and articles thereof.
80 Tin and articles thereof.
81 other base metals; cermets; articles thereof.
82 Tool, implement, cutlery, spoon & fork, of base met etc
83 Miscellaneous articles of base metal.
84 Nuclear reactors, boilers, mchy & mech appliance; parts
85 Electrical mchy equip parts thereof; sound recorder etc
86 Railw/tramw locom, rolling-stock & parts thereof; etc
87 Vehicles o/t railw/tramw roll-stock, pts & accessories
88 Aircraft, spacecraft, and parts thereof.
89 Ships, boats and floating structures.
90 optical, photo, cine, meas, checking, precision, etc
91 Clocks and watches and parts thereof.
92 Musical instruments; parts and access of such articles
93 Arms and ammunition; parts and accessories thereof.
94 Furniture; bedding, mattress, matt support, cushion etc
95 Toys, games & sports requisites; parts & access thereof
96 Miscellaneous manufactured articles.
97 Works of art, collectors' pieces and antiques.
98 Special Classification Provisions
99 Special Transaction Trade.

Note: Descriptions are from OECD International Trade by Commodity Statistics

A-3. Classification of Regions

(1) Hokkaido; (2) Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima; (3) Ibaragi, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa; (4) Niigata, Toyama, Ishikawa, Fukui, Yamanashi, Nagano, Gifu, Shizuoka, Aichi; (5) Mie, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama; (6) Tottori, Shimane, Okayama, Hiroshima, Yamaguchi; (7) Tokushima, Kagawa, Ehime, Kochi; (8) Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima; (9) Okinawa.

A-4. Classification of Industries by SNA

(1) Agriculture, (2) Forestry, (3) Fisheries, (4) Mining, (5) Foods, (6) Textile, (7) Pulp & Paper, (8) Chemical, (9) Petroleum, (10) Stone clay, (11) Primary metal, (12) Fabricated metal, (13) Machinery, (14) Electrical equipment, (15) Transportation equipment, (16) Instruments, (17) Other manufacturing, (18) Service

A-5. Correspondence Table for HS2 industries and SNA industries

HS2	SNA	HS2	SNA	HS2	SNA	HS2	SNA	HS2	SNA
1	1	21	5	41	17	61	17	81	12
2	1	22	5	42	17	62	17	82	12
3	3	23	5	43	17	63	17	83	12
4	1	24	5	44	17	64	17	84	13
5	1	25	10	45	17	65	17	85	14
6	2	26	10	46	7	66	17	86	15
7	1	27	8	47	7	67	17	87	15
8	1	28	8	48	7	68	10	88	15
9	1	29	8	49	18	69	10	89	15
10	1	30	8	50	6	70	10	90	16
11	5	31	8	51	6	71	4	91	16
12	5	32	8	52	6	72	11	92	17
13	5	33	8	53	6	73	12	93	17
14	5	34	8	54	6	74	12	94	17
15	5	35	8	55	6	75	12	95	17
16	5	36	8	56	6	76	12	96	17
17	5	37	8	57	6			97	18
18	5	38	8	58	6	78	12		
19	5	39	9	59	6	79	12		
20	5	40	17	60	6	80	12		

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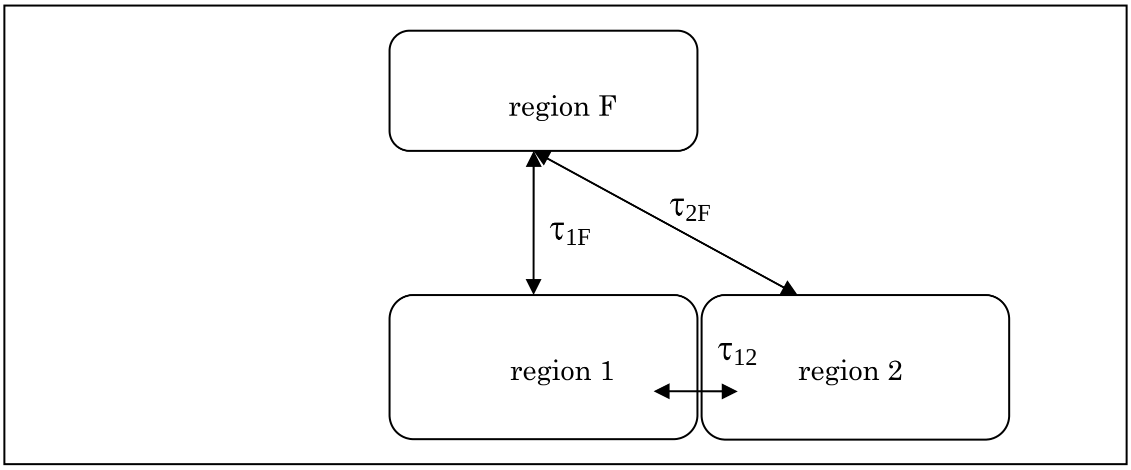
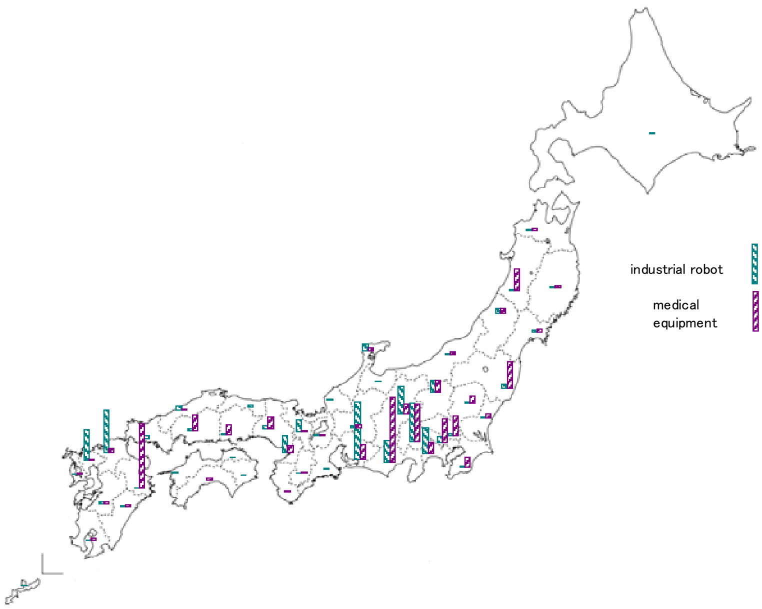
Figure 1. The geography of the two home region and one foreign region model



Note: Regions 1 and 2 represents the Home country and region F is a foreign country. International trade costs are represented by the length of arrows between two regions.

Figure 2. Regional production in 2005:
Industrial robot [JSIC2698] and medical equipment [JSIC3131]



Note: The value of production for each industry in the prefectures are represented in a relative height of bar. The figures are calculated by authors, using the *Census of Manufacturing*.

Table 1. Estimation of export and production equations

	Specification (1)	Specification (2)
	FIML	FIML
Export equation		
ln PRO	1.632	1.634
	(0.018)	(0.018)
DIST	-0.0013	-0.0013
	(0.00004)	(0.00004)
ln Wage	-0.271	-0.271
	(0.085)	(0.085)
ln GDPIM	4.162	4.193
	(0.058)	(0.058)
D_industry	yes	yes
D_importer	yes	yes
R^2	0.52	0.52
Production equation		
(D_dist)(ln GDPIM)	0.015	
	(0.001)	
D_dist		0.476
		(0.030)
ln GDPIM		-0.031
		(0.007)
ln POP	1.455	1.452
	(0.007)	(0.007)
D_industry	yes	yes
R^2	0.80	0.80
NOB	17,813	17,813
Log likelihood	-63427	-63422

Note: The panel sample consists of 9 Japanese regions, 8 Asian countries, 18 industries, and 17 years. Estimation method is full-information maximum likelihood which simultaneously estimates export equation and production equation. The figures in parenthesis are standard errors. D_dist is the distance indicator variable defined as log of average distance over region specific distance. Specification (1) uses an interaction term for distant indicator variable and foreign income whereas specification (2) has these variables in a separate form.