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Abstract

We present a two-country model with explicit incorporation of two regions in the home country and one region in a foreign country. Each region consists of two types of workers: skilled workers, freely mobile across domestic regions, are required to set up a firm, whereas unskilled workers are constrained to their own regions. Trade costs accrue both intra-nationally and internationally. International trade costs are assumed to be different among regions. Our model produces a region-based gravity equation and generates heterogeneity among regional exports in terms of responses with respect to economic size. We also find a home-market effect at the regional level. Moreover, we are able to show the relative magnitude of the home-market effect among home regions, in terms of a change in the export share. The magnitude of the home-market effect is larger in a region further away from the foreign country. We empirically test our theoretical hypothesis with an application to the export dataset of Japanese regions. Our empirical results provide strong evidence in support of a region-based home-market effect but weak evidence for a relative home-market effect.

Keywords: Home-market effect; International trade; Regional exports; Regional heterogeneity; Trade cost.
JEL Classification Codes: F12; F14; R12

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1. Introduction

In classical or (new) new trade models, we assume *heterogeneity* in several features of the economy; namely, factors of production, the productivity of industries, and products within an industry. In a Heckscher-Ohlin type model, the difference in the ratio of factors of production provides opportunity for gains from trade. In a Ricardian-type model, industries are different in terms of their productivity, whereas in a Krugman-type model, consumers' preferences for variety support differentiated products within an industry. Moreover, Melitz (2003) adds another dimension of heterogeneity in terms of the productivity of firms. However, with only a few exceptions, trade models do not seriously address geographical features within a country, although models in new economic geography explicitly model regions within a country.

Studies explicitly incorporating regional heterogeneity within a country include three-region models of Krugman and Elizondo (1996) and Takahashi (2003) as well as four-region models of Behrens et al. (2006, 2007). Krugman and Elizondo (1996) consider a model with one foreign and two domestic regions. However, the two domestic regions are homogeneous and symmetric in the sense that the international transportation cost is set equal for both domestic regions. In contrast, Takahashi (2003) considers a three-region model with explicit geographical heterogeneity in two home regions, in terms of distance to a foreign country. Behrens et al. (2006, 2007) both consider a four-region model in which each of two countries consists of two regions. Behrens et al. (2006) considers the asymmetry with regard to international transportation costs, whereas international trade costs are assumed to be the same for any pair of regions in Behrens et al. (2007). Behrens (2006) assumes asymmetric international trade costs in the sense that one region is restricted to export via the other region.

In this paper, we present a trade model in which two heterogeneous regions exist within a country by introducing region-specific international trade costs, extending the model of Behrens et al. (2006, 2007). 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. In this manner, our model can be considered an extended model of Krugman and Elizondo (1996)[1] and Takahashi (2003). Our model differs from Takahashi (2003) in the assumption of market structures. Our model assumes monopolistic competition markets for differentiated products in three

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

regions, whereas two home regions produce homogeneous products in Takahashi (2003).[2] Following Behrens et al. (2006, 2007), the economy in this paper consists of two types of workers. Skilled workers are freely mobile across domestic regions, whereas unskilled workers are constrained to their own regions. Exogenously, home regions only differ in terms of international trade costs in this paper. Due to this asymmetry in international trade costs, the prices of differentiated goods are region-specific. Thus, skilled workers migrate to the region in which they can earn higher real wages, resulting in another asymmetry in the share of skilled workers among home regions.

It is noteworthy to emphasize that the objective of this paper is substantially different from previous studies investigating three-region or four-region models. These existing studies all focus on the effect of reductions to trade barriers on domestic agglomeration (dispersion) of industries. Little has been written about the effects on international trade. On the contrary, this paper examines the effect of economic size as well as the trade cost effect on regional exports to obtain a region-based gravity equation. In this paper, imposing *regional heterogeneity by assumption* with regard to trade costs allows us to derive some *regional heterogeneity*.

First, the regional exports are shown to be heterogeneous in terms of responses with respect to economic size. Specifically, we demonstrate that regional exports may decline with respect to the size of the foreign country. This result stands in contrast with the general hypothesis of the gravity equation in which international trade increases with respect to either size of the importing or exporting country. Second, the export share of a region further from the foreign country decreases (increases) with respect to the size of the foreign (home) country. As a corollary to this second finding, we are able to show the relative magnitude of the home-market effect among home regions. The magnitude of the home-market effect is larger in a region further away from the foreign country. Finally, we empirically test our theoretical hypothesis with an application to the export dataset of Japanese regions. Our empirical results provide strong evidence in support of a region-based home-market effect but weak evidence for a relative home-market effect.

The structure of the rest of the paper is as follows. The next section introduces the two-country model with regional heterogeneity in international trade costs. In section 3, we show that the regional version of the home-market effect also holds in our

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

model. We further examine the effect of the change in the labor force in the foreign country on the export of home regions and show that the relative magnitude of the home-market effect among regions is important. Then, section 4 empirically examines predictions of the theoretical model with applications to Japanese regional export data. We find strong support for the home-market effect and the export share predictions. The last section discusses the possible extensions of our approach and concludes.

2. The model

The economy consists of two countries: home, *H*, and foreign, *F*. Country *H* has two regions labeled 1 and 2, whereas country *F* has only one region. In this economy, there are two factors of production: skilled and unskilled labor. We assume that the amount of skilled and unskilled workers can be different in two countries. We denote the mass of skilled labor in country i as L_i. In addition, the number of unskilled workers in *H* and *F* are denoted by A_H and A_F, respectively. Moreover, we assume that the same technology is accessible by the two countries.

Each individual works and consumes in the region in which she lives. Skilled workers are mobile between regions but immobile between countries, whereas unskilled workers are assumed to be immobile. The share of skilled workers in region 1 in *H* is denoted by $\lambda \in [0,1]$. We first solve the model in the following subsection by taking the share of skilled workers as fixed. Then, in subsection 2-2, we analyze long-run equilibrium by allowing skilled workers to move freely across regions within a country.

2-1. Equilibrium when skilled workers are immobile across regions

Each consumer is endowed with one unit of labor, which she supplies inelastically. Consumers have a quasi-linear preference for a homogeneous good and differentiated consumption goods. We choose the homogeneous good as numeraire. The sub-utility over the total mass of N of varieties of the differentiated good enters as quadratic, as in Ottaviano et al. (2002). An individual consumer solves the following problem:

$$\max_{q(v),\forall\in[0,N]} \quad \alpha\int_0^N q(v)dv - \frac{\beta-\gamma}{2}\int_0^N [q(v)]^2 dv - \frac{\gamma}{2}\left[\int_0^N q(v)dv\right]^2 + q_0, \tag{1}$$

$$s.t. \int_0^N p(v)q(v)dv + q_0 = y + \bar{q}_0,$$

where $\alpha > 0$, $\beta > \gamma > 0$ are parameters, $p(v)$ is the price of variety v and y is the consumer's income, which depends on the types of workers. In this expression, α

measures the intensity of preference for the differentiated good with respect to the numeraire. The condition $\beta > \gamma$ presents that workers have a preference for variety. We assume that each worker has, in addition to her wage, sufficiently large endowments $\bar{q}_0$ of the numeraire.

Solving this problem for consumers, we find the demand function presented as follows:

$$q_{rs}(v) = a - (b + cN) p_{rs}(v) + cP_s, \tag{2}$$

where $q_{rs}(v)$ is the demand for variety v produced in region r and consumed in region s, whereas $p_{rs}(v)$ is the price of variety v produced in region r and consumed in region s. For the simplicity of notation, we define new variables as follows:

$$a \equiv \frac{\alpha}{\beta + (N-1)\gamma}, \quad b \equiv \frac{1}{\beta + (N-1)\gamma}, \quad c \equiv \frac{\gamma}{(\beta - \gamma)[\beta + (N-1)\gamma]}.$$

These are positive bundles of parameters. If Λ_{rs} denotes the set of varieties produced in region r and consumed in region s, the price index in region s is as follows:

$$P_s \equiv \int_{\Lambda_{1s}} p_{1s}(v)dv + \int_{\Lambda_{2s}} p_{2s}(v)dv + \int_{\Lambda_{Fs}} p_{Fs}(v)dv. \tag{3}$$

Now, we turn to the supply side. There are two sectors in the economy. One sector produces the homogeneous good under perfect competition using unskilled labor as the only input with constant returns to scale technology. The unit input requirement is set to one. The other sector consists of monopolistically competitive firms producing a continuum of varieties of the horizontally differentiated good using both types of labor under increasing returns to scale technology. We assume that the firms can differentiate their products at no cost. Therefore, one firm produces only one variety. Thus, the number of firms is equal to the number of varieties in the economy.

Each firm in a monopolistically competitive sector incurs fixed costs of $\phi(> 0)$ units of skilled labor, whereas its marginal labor requirement is normalized to zero without loss of generality. From skilled labor market-clearing conditions in each region for any distribution of skilled workers, when n_r (r = 1, 2, and F) stands for the number of firms in each region, λ_i are given by the following forms:

$$n_1 = \frac{\lambda_H L_H}{\phi}, \quad n_2 = \frac{(1-\lambda_H)L_H}{\phi}, \quad n_F = \frac{L_F}{\phi}. \tag{4}$$

Moreover, when $n_i (i = H, F)$ and N denote the number of varieties in H, that of F, and that of the economy, respectively, these are presented by the following forms:

$$n_H = n_1 + n_2 = \frac{L_H}{\phi}, \quad n_F = \frac{L_F}{\phi}, \quad N = n_H + n_F = \frac{L}{\phi}. \tag{5}$$

Now, we explain transportation technology. First, the shipping of the homogeneous good 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. Regarding transportation technology for the differentiated goods, both interregional and international transports incur in terms of the numeraire. As for interregional transportation costs within a country, it is assumed that the shipping of a differentiated good between regions 1 and 2 incurs τ_H. Henceforth, we refer to the interregional transportation costs as *domestic trade costs*.

Finally, we suppose that international trade costs are region-specific. That is, all regions do not necessarily have equal access to a region in the other country. International trade costs are asymmetric among home regions, while those costs are assumed be symmetric for any pair of two regions. Namely, when the international trade costs between region r and F are denoted by τ_{rF}, it holds that $\tau_{rF} \neq \tau_{sF}$ and $\tau_{rF} = \tau_{Fr}\ (r = 1.2)$. We refer to the international transportation costs as *international trade costs*.[3] In addition to region-specific international trade costs, we assume that one of the regions in country *H* has a relative advantage in terms of geographical proximity over country *F*. Specifically, we assume that the international trade cost between region 2 and country *F* is smaller than that between region 1 and country *F*. Moreover, we assume the domestic trade cost is smaller than either of the international trade costs. In short, assumptions with regard to both types of trade costs are summarized as follows: $\tau_{1F} > \tau_{2F} > \tau_H$. To exclude the special case in which region 1 exports by using domestic transportation to region 2 and then ships products from there, we impose another restriction on trade costs: $\tau_{1F} < \tau_{2F} + \tau_H$.[4] Figure 1 depicts our assumptions regarding the geography of regions in this paper.

We focus on the case in which domestic trade costs and international trade costs are sufficiently low that inter-regional and international bilateral trades occur. We will show the conditions under which any bilateral trades between any two regions at the equilibrium prices occur in Appendix A.1. Hereafter, we focus on region 1 because regions are symmetric other than international trade costs.

We make three crucial assumptions for labor and product markets: the product

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[3] If we assume that trade costs increase monotonically in distance, geographical distance can be used as a proxy for trade costs in the later analysis.

[4] This restriction is unnecessary in this model because there is no mechanism that region 1 uses region 2 as an export platform. By imposing this restriction, however, there will be only direct exports, even if the export-platform mechanism is explicitly introduced in the model.

market is segmented, the labor market is local, and entry and exit are free. Under these assumptions, the profit of the firm in region 1 is as follows.

$$\pi_1 = q_{11}\left(\frac{A}{2} + \lambda_H L_H\right)p_{11} + q_{12}\left(\frac{A}{2} + (1-\lambda_H)L_H\right)(p_{12} - \tau_H) \\ + q_{1F}(A_F + L_F)(p_{1F} - \tau_{1F}) - w_1\phi. \tag{6}$$

The firm in region 1 maximizes this profit with respect to prices p_{11}, p_{12}, and p_{1F}, separately.

The market outcome

Solving the optimization problem for firms producing differentiated goods yields the profit-maximizing prices as a function of the price index, which are shown as follows:

$$p_{11}(P_1) = \frac{a + cP_1}{2(b + cN)}, \tag{7}$$

$$p_{21}(P_1) = \frac{a + cP_1}{2(b + cN)} + \frac{\tau_H}{2} = p_{11} + \frac{\tau_H}{2}, \tag{8}$$

and,

$$p_{F1}(P_1) = \frac{a + cP_1}{2(b + cN)} + \frac{\tau_{1F}}{2} = p_{11} + \frac{\tau_{1F}}{2}. \tag{9}$$

(7), (8) and (9) provide the intraregional, interregional, and international prices, respectively. The prices in one region depend on the price index in this region, which is determined by the price set there by all firms. Because there is a continuum of firms, each firm is negligible and chooses its optimal price, taking aggregate market conditions as given. At the same time, these aggregate market conditions must be consistent with firms' optimal pricing decisions. Therefore, the (Nash) equilibrium price index P_1^* must satisfy the following condition:

$$P_1^* = n_1 p_{11}^*(P_1^*) + n_2 p_{21}^*(P_1^*) + n_F p_{F1}^*(P_1^*). \tag{10}$$

Similar conditions hold for the other regions. Using the profit-maximizing prices and (10) leads to price index, P_1^*:

$$P_1^* = \frac{aN + (b + cN)[n_2\tau_H + n_F\tau_{1F}]}{2b + cN}. \tag{11}$$

Substituting (11) into (7), (8), and (9), we find the equilibrium prices for intraregional, interregional, and international, which are presented by (12), (13), and (14), respectively:

$$p_{11}^* = \frac{2a + c[n_2\tau_H + n_F\tau_{1F}]}{2(2b + cN)},$$
$$p_{22}^* = \frac{2a + c[n_1\tau_H + n_F\tau_{2F}]}{2(2b + cN)}, \tag{12}$$
$$p_{FF}^* = \frac{2a + c[n_1\tau_{1F} + n_2\tau_{2F}]}{2(2b + cN)}$$

$$p_{21}^* = p_{11}^* + \frac{\tau_H}{2} \text{ and } p_{21}^* = p_{22}^* + \frac{\tau_H}{2}, \tag{13}$$

$$p_{F1}^* = p_{11}^* + \frac{\tau_{1F}}{2}, p_{F2}^* = p_{22}^* + \frac{\tau_{2F}}{2}, p_{1F}^* = p_{FF}^* + \frac{\tau_{1F}}{2}, \text{and } p_{2F}^* = p_{FF}^* + \frac{\tau_{2F}}{2}. \tag{14}$$

Note that each equilibrium price decreases with the number of firms located in the corresponding region and increases with both domestic and international trade costs. These two effects are referred to as the *pro-competitive effect* in Behrens et al. (2007). In addition to the pro-competitive effect, it is found that the prices depend on the number of firms in each region. The novel feature of our paper is that each price of the varieties is region-specific. This price is derived from our assumption that international trade costs are region-specific.

Substituting these equilibrium prices into the demand function and using the price indices, the equilibrium consumption level can be derived as follows:

$$q_{11}^* = a - bp_{11}^* + \frac{c}{2}(n_2\tau_H + n_F\tau_{1F}), \tag{15}$$

$$q_{21}^* = q_{11}^* - (b + cN)\frac{\tau_H}{2}, \tag{16}$$

and,

$$q_{F1}^* = q_{11}^* - (b + cN)\frac{\tau_{1F}}{2}. \tag{17}$$

(15), (16) and (17) provide the intraregional, the interregional, and the international demands, respectively. The high domestic trade costs raise the intra-regional and international demands and lower inter-regional demand. Moreover, the higher international trade costs between corresponding regions and the region in the other country increase the intra-regional and inter-regional demands as well as decrease international demand. These effects are interpreted as substitution effects. However, high international trade costs between the other region in its own country and the foreign region do not affect demand.

After solving for equilibrium prices and quantities for a given set of model parameters, we can derive equilibrium export functions for the two regions in the home country. We define the exports of each region as E_1 and E_2, which are aggregated values of variety exports from each region:

$$E_1 = n_1 p_{1F} q_{1F} \left(A_F + L_F \right)$$
$$E_2 = n_2 p_{2F} q_{2F} \left(A_F + L_F \right) . \tag{18}$$

By substituting equilibrium price and demand into equation (18), exports can be represented as the function of the share of skilled workers and the model parameters. However, domestic trade costs, τ_H, and home unskilled workers, A_H, do not affect regional exports.[5]

$$E_1 = E_1(\lambda | \alpha, \beta, \gamma, \phi, L_F, L_H, A_F, \tau_{1F}, \tau_{2F})$$
$$E_2 = E_2(\lambda | \alpha, \beta, \gamma, \phi, L_F, L_H, A_F, \tau_{1F}, \tau_{2F}) \tag{19}$$

Given parameters for preference ($\alpha, \beta,$ and γ) and technology (ϕ), regional exports are shown to be affected by skilled labor in both countries, unskilled labor in foreign countries and international trade costs. 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 type of Gravity model. With the assumption of a fixed skilled worker share in the home country, however, comparative statics analysis is just that of a three-country model. In the following subsection, we investigate equilibrium when skilled workers are free to move across regions in the home country.

2-2. Long-run Equilibrium

The market equilibrium, given a spatial distribution of the skilled in *H*, is determined by using (12) through (17). However, when the skilled labor can migrate between regions, the share of skilled workers (firms) is determined endogenously.

In order to find long-run equilibrium, we have to find the wage of the skilled workers. Firms compete for workers by offering higher wages. This competition continues until no firm can profitably enter or exit the market. As a result, all operating profits are absorbed by the wage bill, and become zero at equilibrium. From (7) and the zero profit condition, the equilibrium wages in region 1 are presented as follows;

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[5] The direct effect of domestic trade costs and home unskilled workers on regional exports does not exist. However, it is important to note that the indirect effect through the share of skilled workers across regions appears when skilled workers are allowed to move freely in the next subsection. Export functions simplified after algebraic manipulations are shown in Appendix A2.

$$w_1^* = \frac{A}{2\phi}\left(p_{11}^* q_{11}^* + p_{12}^* q_{12}^*\right) + \frac{A_F}{\phi} p_{1F}^* q_{1F}^* + n_1 p_{11}^* q_{11}^* + n_2 p_{12}^* q_{12}^* + n_F p_{1F}^* q_{1F}^*$$
$$- q_{12}\tau_H\left(\frac{A}{2} + (1-\lambda)L_H\right) - q_{1F}\tau_{1F}\left(A_F + L_F\right) \qquad (20)$$

Skilled workers move to the region in which they can acquire the higher indirect utility level. The indirect utility level in region r (r=1,2) is obtained by substituting (12) through (17) and (20) into (1). When the indirect utility level of region r is denoted by V_r ($r=1, 2$), this is written as follows:

$$V_r = \alpha\left(n_1 q_{1r}^* + n_2 q_{2r}^* + n_F q_{Fr}^*\right) - \frac{\beta-\gamma}{2}\left[n_1\left(q_{1r}^*\right)^2 + n_2\left(q_{2r}^*\right)^2 + n_F\left(q_{Fr}^*\right)^2\right]$$
$$- \frac{\gamma}{2}\left(n_1 q_{1r}^* + n_2 q_{2r}^* + n_F q_{Fr}^*\right)^2 \qquad (21)$$
$$+ w_r^* + \bar{q}_0 - \left(n_1 p_{1r}^* q_{1r}^* + n_2 p_{2r}^* q_{2r}^* + n_F p_{Fr}^* q_{Fr}^*\right), \qquad r = 1,2.$$

Noting that n_1 and n_2 are determined by the share of skilled workers, λ, the indirect utility differential between the two regions in H is defined as a function of λ. When the differential is denoted by $\Delta V(\lambda)$, this is defined as follows:

$$\Delta V(\lambda) = V_1(\lambda) - V_2(\lambda). \qquad (22)$$

At equilibrium, the skilled workers have no incentive to move between regions. Formally, the equilibrium arises at:

$$\begin{cases} \lambda^* \in (0,1) & when \quad \Delta V(\lambda^*) = 0, \\ \lambda^* = 0 & if \quad \Delta V(\lambda^*) \le 0, \\ \lambda^* = 1 & if \quad \Delta V(\lambda^*) \ge 0. \end{cases}$$

An interior equilibrium is stable if and only if the slope of the indirect utility differential is negative in a neighborhood of the equilibrium, whereas the equilibrium is such that full agglomeration of the skilled workers in one region is always stable whenever it exists. Because the indirect utility differential reveals that this differential is a linear function of λ, we find that the interior equilibrium is stable if and only if the coefficient of λ in this differential around the neighborhood of the equilibrium is negative. It is difficult to find an interior equilibrium analytically. To derive interior equilibrium, we need the numerical analysis as shown later.

For studies intended to provide theoretical explanations for regional agglomerations, equilibria at two extremes are interesting in and of themselves. The model in this paper, however, provides an analytical foundation for exports of multi-regions within a country. We restrict our equilibrium concept to stable existence of the situations, such that all regions export. We restate all parameter restrictions imposed in this paper as far as the following assumptions before our formal definition of the equilibrium concept. All eleven parameters in this model are denoted by $\theta = (\alpha, \beta, \gamma, \phi, L_F, L_H, A_F, A_H, \tau_{1F}, \tau_{2F,} \tau_H)$.

Assumptions:
(A1) All parameters are non-negative. (A2) $\beta > \gamma$. (A3) $\tau_{1F} > \tau_{2F} > \tau_H$. (A4) $\tau_{1F} < \tau_{2F} + \tau_H$.

Definition (Long-run Stable Regional Export Equilibrium):
The set of parameters $\theta = (\alpha, \beta, \gamma, \phi, L_F, L_H, A_F, A_H, \tau_{1F}, \tau_{2F,} \tau_H)$ satisfying assumptions (A1) through (A4) and λ^* is defined to be at a long-run, stable, heterogeneous export (**LSRE**) equilibrium if (i) λ^* is strictly within the range between 0 and 1, (ii) $\Delta V(\lambda^*) = 0$ (iii) $d\Delta V(\lambda^*) \big/ d\lambda \leq 0$ and (iv) both E_1 and E_2 are strictly positive.

The first condition implies that some skilled workers always remain in each home region. We need to be careful that this condition assures that there will be production of differentiated products in each region but not exports of these products. The second and third conditions require that the share of skilled workers is endogenously determined and stable. The fourth condition requires that both regions actually export. The random choice of numerical values for 11 parameters guarantees condition (ii) holds for some λ but not the other three conditions. The fourth equation can be met if domestic and international trade costs are smaller to the threshold value, which is a function of $\alpha, \beta, \gamma, \phi, L_F, \text{and } \mathrm{L_H}$. This condition is provided in Appendix A1.

3. Home-market effect and relative home-market effect

In this section, we investigate the effects of the changes in international trade costs and in the population of both *H* and *F* on the value of regional exports. We therefore aim to investigate the regional version of the gravity model.[6]

3-1. Analytical results

[6] 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).

Now, we define the value of exports of region 1 as E_1 represented as follows:

$$E_1 = n_1^* p_{1F}^* q_{1F}^* \left(A_F + L_F\right). \tag{23}$$

First, we show the effect of the change in international trade costs on the value of regional exports. Then, we present the effect of the change in the size of workers in home and foreign countries on the value of regional exports. Before we show a comparative analysis, we must address that the number of firms in a region, the equilibrium prices and the equilibrium demands are affected by model parameters through the change in the number of skilled workers. The direction of these indirect effects cannot be derived analytically. We will show results from numerical analysis in the later subsection.

Trade Cost Effect

From the definition of the value of regional exports, the decrease in international trade costs affect regional exports through the change in the number of firms and the value of individual exports, which are in turn caused by the migration of skilled workers as shown in (24):

$$\frac{\partial E_1}{\partial \tau_{1F}} = \left(A_F + L_F\right)\left[p_{1F}^* q_{1F}^* \frac{\partial n_1^*}{\partial \tau_{1F}} + n_1^* \frac{\partial p_{1F}^* q_{1F}^*}{\partial \tau_{1F}}\right]. \tag{24}$$

The effect of the change in international trade costs on the number of firms in region 1 is:

$$\frac{\partial n_1^*}{\partial \tau_{1F}} = n_H \frac{\partial \lambda^*}{\partial \tau_{1F}}. \tag{25}$$

The effect on the value of individual exports is presented as follows:[7]

$$\frac{\partial p_{1F}^* q_{1F}^*}{\partial \tau_{1F}} = \frac{\left(2b + cN + 2cn_1^*\right)q_{1F}^* - \left[c^2 n_1^* N - \left(b + cN\right)\left(2b + cN\right)\right]p_{1F}^*}{2\left(2b + cN\right)} + \frac{cn_H\left(\tau_{1F} - \tau_{2F}\right)\left(2q_{1F}^* + cNp_{1F}^*\right)\dfrac{\partial \lambda^*}{\partial \tau_{1F}}}{2\left(2b + cN\right)}. \tag{26}$$

The effect of the change in trade costs on the export of region 1 has direct and indirect effects. It is clear that the direct effects of the changes in international trade costs between region 1 and F on the value of exports from region 1 are positive. Moreover, it is clear that the coefficient of $\partial \lambda^* / \partial \tau_{1F}$ is positive due to the assumption of

7 Note that both price and demand depend on international trade costs. The effect of the change in international trade costs on both price and demand are shown and explained in Appendix A.3.

international trade costs. Substituting (25) and (26) into (24) derives the overall effect of the change in international trade costs on the value of exports. In addition, the value of exports of region 1 is affected by not only τ_{1F} but also τ_{2F}.[8] It is important to note that the value of exports from one region is affected by trade costs between the other region and the foreign country, which is derived from introducing region-specific trade costs. This result is a new feature.

Labor Force Effect

Next, we derive the effect of the change in the population of both types of labor in the foreign country on the value of exports of region 1. The overall effect consists of three effects as shown in (27) and (28).

$$\frac{\partial E_1}{\partial L_F} p_{1F}^* q_{1F}^* \left(A_F + L_F\right) \frac{\partial n_1^*}{\partial L_F} + n_1^* \left(A_F + L_F\right) \frac{\partial p_{1F}^* q_{1F}^*}{\partial L_F} + n_1^* p_{1F}^* q_{1F}^* . \quad (27)$$

$$\frac{\partial E_1}{\partial A_F} = p_{1F}^* q_{1F}^* \left(A_F + L_F\right) \frac{\partial n_1^*}{\partial A_F} + n_1^* \left(A_F + L_F\right) \frac{\partial p_{1F}^* q_{1F}^*}{\partial A_F} + n_1^* p_{1F}^* q_{1F}^* . \quad (28)$$

(27) is quite similar to (28). The first terms in (27) and (28) provide the indirect effect through the migration behavior of the skilled to region 1. It must be noted that given the value of foreign demand for each variety, a change in the number of varieties in region 1 affects total exports of region 1. The second terms in (27) and (28) state the indirect effect through the change in the individual demand for a variety. The last terms in (27) and (28) demonstrates the direct effect on the export due to the change in the population of the foreign country, which is obviously positive. Here, we investigate the first and second terms.

The effects of the changes in the population of both types of labor in *F* on the number of firms in region 1 are affected through migration of the skilled in *H*. For example, the effect of the changes in the number of the skilled in *F* is $\partial n_1^* / \partial L_F = n_H \left(\partial \lambda^* / \partial L_F\right)$. The effect of the change in the number of unskilled workers in *F* is similar. It is noteworthy that the sign of the first term in exports of region 2 should be opposite because $\partial n_2^* / \partial L_F = -n_H \left(\partial \lambda^* / \partial L_F\right)$. These opposite effects can result in an increase in exports for one region and a decrease in exports for the other region if the effect on the share of skilled workers in the home country of a change in foreign labor overwhelms the net of other effects.

The indirect effect of the change in the number of skilled workers in *F* through the change in the individual demand for a variety shown by the second term in (27) is found to be $\partial p_{1F}^* q_{1F}^* / \partial L_F = 2(b + cN) p_{FF}^* \left(\partial p_{FF}^* / \partial L_F\right)$. The change in the number of the

[8] The cross effect of trade cost on regional export is derived in the appendix A3.

unskilled in F is similar. From this equation, it is clear that the sign of this derivation depends on that of $\partial p_{FF}^{*} / \partial L_F$. The overall effect of the export function is found by substituting these two indirect effects into (27) and (28).

Next, we derive the effect of the increase in the population of both types of labor in H on the value of exports of region 1. The overall effect is found to consist of two effects.

$$\frac{\partial E_1}{\partial L_H} = p_{1F}^{*} q_{1F}^{*} \left(A_F + L_F\right) \frac{\partial n_1^{*}}{\partial L_H} + n_1^{*} \left(A_F + L_F\right) \frac{\partial p_{1F}^{*} q_{1F}^{*}}{\partial L_H}. \qquad (29)$$

$$\frac{\partial E_1}{\partial A_H} = p_{1F}^{*} q_{1F}^{*} \left(A_F + L_F\right) \frac{\partial n_1^{*}}{\partial A_H} + n_1^{*} \left(A_F + L_F\right) \frac{\partial p_{1F}^{*} q_{1F}^{*}}{\partial A_H}. \qquad (30)$$

In addition, (29) is quite similar to (30). The first terms in (29) and (30) provide the indirect effect through the migration behavior of the skilled to region 1. The second terms in (29) and (30) present the indirect effect through the change in the value of individual exports.

The change in the population of the skilled in H has two effects as shown below.

$$\frac{\partial n_1^{*}}{\partial L_H} = \frac{\lambda^{*}}{\phi} + n_H \frac{\partial \lambda^{*}}{\partial L_H}. \qquad (31)$$

The first term in (31) presents a direct effect of the change in the number of firms in H, which is caused by the change in the number of the skilled in H. This first term is positive. The second term in (31) states the indirect effect through the migration of the skilled. Whereas the effect of the change in the number of the skilled in H has two channels, the change in the number of the unskilled in H affects only through indirect effects similar to the change in the population of workers in F.

The indirect effect of the change in the number of skilled workers in H through the change in the individual demand for a variety shown by the second term in (29) is found to be $\partial p_{1F}^{*} q_{1F}^{*} / \partial L_H = 2(b + cN) p_{FF}^{*} \left(\partial p_{FF}^{*} / \partial L_H\right)$. The change in the number of the unskilled in H is similar. From this equation, it is clear that the sign of this derivation depends on that of $\partial p_{FF}^{*} / \partial L_H$. The overall effect is found by substituting the two indirect effects into (29) and (30).

With explicit implementation of regions within a country, we can also examine the share of regional exports in the home country. The proportion of exports of region 1 is defined as follows.

$$S_1 \equiv \frac{E_1}{E_1 + E_2}. \qquad (32)$$

We will show the effect of the increase in the population of the skilled in F on this proportion.[9] Using some results derived above, we obtain the following relationship.

$$\frac{\partial S_1}{\partial L_F} = S_1(1-S_1)\left\{\left(\frac{1}{n_1}+\frac{1}{n_2}\right)\frac{\partial n_1}{\partial L_F} + \left(\frac{1}{p_{1F}^* q_{1F}^*}\frac{\partial p_{1F}^* q_{1F}^*}{\partial L_F} - \frac{1}{p_{2F}^* q_{2F}^*}\frac{\partial p_{2F}^* q_{2F}^*}{\partial L_F}\right)\right\}. \quad (36)$$

The sign of (36) is determined by that of the equations in parentheses.

As stated above, the effect of the change in parameters on the number of firms in *H* cannot be derived analytically. To acquire results of comparative statistics, we need a numerical analysis. The results will be provided in the next subsection.

3-2. Examination of the Labor Effects by Numerical Analysis

Because of high non-linearity in the solution of the model, the usefulness of the analytical approach is limited. In this subsection, we find a set of parameter values to satisfy our equilibrium concept (LSRE) by the following calibration. Then, we find the effects of labor size on regional exports and the share of exports by numerical analysis.

Parameters calibration

First, we start by choosing numerical values for preference parameters: $\alpha, \beta,$ and γ. We set γ equal to unity as a numeral. Assumption (A2) requires that β needs to be greater than γ. A larger value for α is likely to support equilibrium for positive exports when transportation costs incur because it leads to greater demand. We set $\alpha = 5$ and $\beta = 2$.

Second, we move to 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 in both countries are equal. After evaluating numerous sets of parameter values, we found out that (i) unskilled labor needs to be much larger than skilled labor and (ii) it is necessary for skilled labor in the foreign country to be relatively smaller than that of the home country. We set L_F=0.15, L_H=1.5, and A_F=A_H=200.

Third, we set the skilled labor requirement as a fixed cost, ϕ, equal to 10. It is important to remember that both countries share the same technology so that the change in this parameter has a similar effect as simultaneous changes in the skilled labor in both countries. With numerical examinations, we confirm that this parameter and skilled labor are closely related.

Finally, we need to determine the appropriate values for transportation costs: $\tau_H, \tau_{1F},$ and τ_{2F}. These parameters need to satisfy two assumptions: (A3)

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9 It is obviously found that $\partial S_1/\partial L_F = [(1-S_1)(\partial E_{1F}/\partial L_F) - S_1(\partial E_{2F}/\partial L_F)]/(E_1 + E_2)$.

$\tau_{1F} > \tau_{2F} > \tau_H$ and (A4) $\tau_{1F} < \tau_{2F} + \tau_H$. Moreover, these parameters cannot exceed the threshold values in order to have strictly positive values of trade. The conditions for positive exports are derived in the Appendix A1. We set τ_{1F} =4.9, τ_{2F} =4.8, and τ_H =2.

With these parameter values, we obtain **LSRE** equilibrium in which the share of skilled workers in region 1 is 0.409634. The only regional heterogeneity by assumption is the difference in international trade costs and the approximate two percent difference in trade costs results in the 20 percent difference in the share of skilled workers. The effect of the difference in international trade costs on regional exports is more pronounced: export values are 1.64636 for region 1 and 6.67087 for region 2. We confirm that the distance effect in the general gravity model still holds for our intra-national regional model.

Numerical analysis and home-market effects

With regard to the effect of the size of the economy on regional exports, the results from numerical analysis are shown in Figure 2 and then are summarized in Table 1.[10] We obtain three noteworthy features from the numerical simulations. First, the most important result is that the well-documented economy size effect in the gravity model does not necessarily hold in our intra-national regions model. An increase in foreign labor may decrease regional exports. Second, the effect of the foreign labor size on regional exports may be opposite in the sign. For an increase in unskilled workers in the foreign country, the exports of region 1 decrease, whereas the exports of region 2 increase. Third, the effect of the labor size on regional exports may differ depending on the type of labor. For region 2, an increase in foreign skilled labor lowers exports, whereas an increase in foreign unskilled labor raises exports.

Given these expected signs of labor size effects from numerical analysis, we can also discuss whether the home-market effect arises in international trade at the intra-national region level. Krugman (1980) originally proposed that the home country will be a net exporter of products for which the home country has a relatively larger home-market (than the foreign market). Feenstra et al. (2001) show that the home-market effect can be tested in the gravity equation. The home-market effect implies that the elasticity of home country exports with respect to domestic income is larger than that with respect to foreign income. In terms of our analytical framework, there exists a home-market effect if $\partial E_1/\partial L_H > \partial E_1/\partial L_F$ holds. By comparing the signs of labor effects on regional exports in Table 1, predictions for the home-market

[10] It should be noted that the solutions always satisfy the LSRE equilibrium for the set of parameter values used in numerical analysis.

effect for regional exports are summarized in the following Hypothesis 1.

Hypothesis 1 (home-market effect):
The home-market effect (*HME* holds for exports for region 1 regardless of labor type. *HME* holds for exports for region 2 when the size of economy is measured with skilled labor. For region 2, it is ambiguous whether or not *HME* holds when the size of economy is measured by unskilled labor.

The original version of the home-market effect is constructed on the basis of a relatively larger increase in exports for the home-market than the foreign market. In the original version, it is necessary to compare the magnitudes of the effects of the change in the size of countries because exports increase with respect to the growth of both countries. In this model, the home-market effect is more straightforward when the size of the economy changes with respect to skilled labor because only home market expansion raises regional exports. We did not rely on the magnitudes of the labor effect from the numerical simulation, which is why the effect of unskilled labor on region 2 is undetermined.

Next, we consider the share of exports of each region within a country. Because the studies on international economics have focused on aggregate national variables, the analysis for the regional share has not been exploited. Our setting allows us to examine the export share of regions. For drawing predictions of the effect of labor on export share, we need to resort to numerical analysis of export share excluding unskilled foreign labor. The result of the numerical analysis for export share is shown in Figure 3. This result is summarized as the following Hypothesis 2.

Hypothesis 2 (export share)
The export share of region 1 decreases with an increase in both types of foreign labor and increases with an increase in home unskilled labor. The effect on export share is ambiguous with an increase in home skilled labor.

Because the signs of the effect of the change in unskilled foreign labor are opposite for exports of the two regions (the first two columns in Table 1), we can draw the result from Hypothesis 1. For other cases, we need to rely on direct numerical analysis on export share. From Figure 3, we can confirm that the labor effects are robust within the range of simulated values for parameters, except for home skilled labor.

Previous empirical studies on the home-market effect focus on whether or not the home-market effect can be found with an international dataset. In this study, we can take a further step to compare the degree of the home-market effect across regions within a country because we explicitly model two regions in the home country. From Hypothesis 2, we can predict the relative magnitude of the home market effect when labor is measured by the number of unskilled workers. We call this result the *relative home-market effect* for convenience.

Hypothesis 3 (relative home-market effect)
The degree of the home-market effect is likely to be stronger in region 1, such that export shares increase (decrease) with respect to home (foreign) unskilled labor. The following inequality holds: $\partial E_1/\partial A_H > \partial E_2/\partial A_H > \partial E_2/\partial A_F > \partial E_1/\partial A_F$ if $\partial S_1/\partial A_H > 0$ & $\partial S_1/\partial A_F < 0$

To derive the inequalities in Hypothesis 3, we have to recall four inequalities. First, in Hypothesis 1, it is shown that the home-market effect exists for regions 1 with respect to unskilled labor, i.e., $\partial E_1/\partial A_H > \partial E_1/\partial A_F$. Then, from Hypothesis 2 we know that the export share decrease when the population of unskilled labor increases in the foreign country. This implies inequality $\partial E_2/\partial A_F > \partial E_1/\partial A_F$ tends to hold.[11] In addition, Hypothesis 2 states that the export share increases when the population of home unskilled labor increases, implying another inequality $\partial E_1/\partial A_H > \partial E_2/\partial A_H$. Finally, if the home-market effect with respect to unskilled labor exists for region 2, then $\partial E_2/\partial A_H > \partial E_2/\partial A_F$ holds.[12] In summary, if we assume the home-market effect applies to both regions, then these inequalities imply that $\partial E_1/\partial A_H > \partial E_2/\partial A_H > \partial E_2/\partial A_F > \partial E_1/\partial A_F$.

Given the result of Hypothesis 1, we can test for the home-market effect by comparing estimated coefficients of the foreign economy and regional economy in a gravity model regression. With Hypothesis 2, we estimate a gravity-type regression with the export share as a dependent variable. With Hypothesis 3, we test the relative

[11] Strictly speaking, the equation in footnote 9 implies the comparative size of the share of weighted differentials; $(1-S_1)\,\partial E_1/\partial A_F < S_1\,\partial E_2/\partial A_F$.

[12] Recall that in Feenstra et al. (2001) the home-market effect was investigated by comparing the size of income elasticity of exports between home and foreign. For example, we can say the home-market effect exists for the exports of region 1 with respect to skilled labor when $\partial E_1/\partial L_H > \partial E_1/\partial L_F$ holds. It is noteworthy that Hypothesis 1 does not assure the existence of a home-market effect with respect to unskilled workers for region 2 because the signs of effects are the same for home and foreign.

home-market effect by comparing estimated coefficients of the foreign economy and regional economy in an export share gravity model regression.

4. An Application to Japanese Exports

Figure 4 shows how the production of industry can be sparsely distributed across the nation: production in 2005 for industrial robot and medical equipment. This figure can provide the intuition that production is relatively dispersed across regions within a country; however, it falls short in explaining what exports from these regions may look like. We use port-level export data of Japan in this section to address the region-based hypotheses provided in the previous section.

Data

Export data are taken from the database of Japanese Customs, the Ministry of Finance. Japanese Customs provides finely disaggregated export data for each international port/airport in addition to national aggregate export data. 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. In the first step, HS 9-digit commodities are aggregated over HS 2-digit industries.[13] For the second step, we aggregated these port-level exports at the HS 2-digit level for each prefecture. 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 their prefectures. Firms in these prefectures export from ports in another prefecture. Similarly, there exist some firms, especially near the border, that use international ports in adjacent prefectures. To minimize this cross-border export effect on our estimates, we grouped 47 prefectures into nine regions. In the last step, we constructed the export series at the HS 2-digit level for nine regions in Japan. The details of these regions are given in Appendix A.5. Eight destination countries were selected: China, Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand.

Regional GDP is constructed based on the Japanese Prefecture Income. For the years between 1990 and 2004, continuous series are readily available. We added two additional years prior to 1990 and after 2004 from different report files. Regional employment data is 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 terms of current US dollars are converted to Japanese yen values by the period's average foreign exchange rates. All series are adjusted to be

[13] Descriptions for these HS 2-digit industries are provided in Appendix A5.

expressed in terms of one unit of Japanese yen.

The distance between the Japanese regions and Asian countries is measured in two steps. First, the distance to each Asian country is measured from each prefecture. 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.

4-1. Estimation Model for Regional Exports

For each HS 2-digit industry, we estimate the following export equation in a panel framework:

$$E_{ijt} = \mathbf{X}_t \boldsymbol{\beta} + \varepsilon_{ijt} = \beta^i + \beta^j + \beta_1 L_{it} + \beta_2 L_{jt} + \beta_3 \tau_{ij} + \varepsilon_{ijt} \quad (37)$$

where $\mathbf{X}_t$ is a row vector of explanatory variables and $\boldsymbol{\beta}$ is a column vector of coefficients. β^i and β^j are fixed effects for Asian country (*i*) and Japanese region (*j*), respectively; L_{it} and L_{ji} are the size of the economy for Asian country (*i*) and Japanese region (*j*); and τ_{ij} is the trade cost between the Asian country (*i*) and the Japanese region (*j*). For the size of the economy, L_{it} and L_{ji}, the gross domestic product and population, are used alternatively. As a proxy to trade cost, we use distance between an importing country and a region in Japan.

Table 2 provides estimated coefficients for the gross domestic product of importing countries and Japanese regions, as well as for distance. In conformity with the results of other trade models, the expected signs of both economy size variables are positive: $\beta_1 > 0$ and $\beta_2 > 0$. The estimated coefficients in the first and second columns show that the income effect of both the importing country and the region is positive for all industries. The third column in Table 2 indicates that estimators for distance are negative for all industries. Thus, the result achieved using our region-based gravity model is quite consistent with previous empirical studies using country-based gravity models.

However, this result is not quite consistent with predictions of our theoretical model. Our theoretical model is consistent for the effect of foreign labor with empirical results only if unskilled labor is considered for region 2. In Table 1, the effect of foreign labor is negative for other cases. We will come back to this issue in the next subsection.

Next, we turn to the home-market effect. Our intra-national regional theoretical model predicts the relative size of these coefficients as the home-market effect: $\beta_2 > \beta_1$. We test this hypothesis formally, using a one-sided test with the null hypothesis of H0: $\beta_2 - \beta_1 = 0$ against the alternative H1: $\beta_2 - \beta_1 > 0$.

$$\text{HME} = \frac{\beta_2 - \beta_1}{\sqrt{Var(\beta_1) + Var(\beta_2) - 2Cov(\beta_1, \beta_2)}} \quad (38)$$

We use the statistics in equation (38) as HME test statistics, for which the distribution is asymptotically normal under regular conditions.

Table 2 also provides HME test statistics along estimated coefficients for economic size and trade costs. The HME, surprisingly, holds for almost all industries when the statistical significance level is at ten percent. There were only 4 out of 96 industries for which the null hypothesis could not be rejected[14]. Even for the five-percent statistical significance level, there were only 15 industries for which the null hypothesis could not be rejected. However, at the one-percent statistical significance level, industries with home-market effects became a smaller portion of the entire body of industries; 33 industries still allowed the rejection of the null hypothesis and therefore demonstrate home-market effects.

The noteworthy element here is that there seems to be no relationship between the degree of HME and industry characteristics. Industries with the highest HME statistics are HS2 (meat), HS8 (fruits and nuts), HS10 (cereals), HS11 (products of cereals), HS24 (tobacco), and HS79 (zinc and zinc products). The most highly differentiated product industries, such as HS84 (general machinery), HS85 (electrical appliances), HS87 (vehicles), and HS90 (precision machinery), do not appear in the extreme cases.

We also replaced population with gross domestic product in estimation equation (37) and obtained qualitatively similar results for all coefficients. For all industries, β_1 and β_2 are positive and β_3 is negative. The size of β_1 is larger than that of β_2. However, HME statistics could not reject the null hypothesis of there being no home-market effect[15]. This inconsistency with our theoretical predictions when the population variable is used may be related to the assumption of a Ricardian-type of production in the model versus the use of many factors of production in the real world. For theoretical tractability and expositional purposes, we assumed that production uses only two types of labor. Labor is simultaneously the only factor of production and consumers in the model. However, using labor as the explanatory variable in an empirical model may undermine the effect of economy size on exports.

[14] These industries are HS1 (live animals), HS50 (silk), HS75 (nickel and nickel products), and HS93 (arms and ammunition).

[15] The regression results when population is used to indicate the size of economy can be made available upon request to the authors.

4-2. Robust Estimation Addressing Zero Trade

Given the well-known fact that trade data can contain many zeros, especially when disaggregated data is used, the ordinary least squares method may not produce efficient estimators.[16] We therefore estimated the same empirical model using probit estimation.

$$\Pr ob(E_{ijt} > 0 \mid X_t) = \Phi(\mathbf{X}_t \boldsymbol{\beta}) \tag{39}$$

where Φ denotes the standard normal distribution function, and $\mathbf{X}_t\boldsymbol{\beta}$ is given in equation (37).

The result of the probit estimation is given in Table 3. The coefficients for Japanese regional income are positive and large in magnitude for all industries, while the signs of the coefficients for the income of importing countries are negative for 44 industries. The estimated negative effect of the size of the foreign economy on exports is not standard in empirical studies. However, these are consistent with theoretical findings summarized in Table 1.

With regard to the home-market effect, in comparing the size of coefficients β_1 and β_2, we obtained even stronger support for home-market effects than in the previous subsection. Even at a one-percent statistical significance level, only two industries indicate no evidence of the home-market effect. Table 3 also reworks the order of industries according to the value of HME statistics. More interestingly, the order of industries is very different from the ones in Table 2. The top three industries with the highest HME statistics are HS37 (photographic products), HS30 (pharmaceutical products), and HS92 (musical instruments). These industries may be categorized as differentiated-product industries. We should not take these three samples as representative of the entire sample because we also find homogenous product industries with very high HME statistics. On the other hand, the lowest three industries are HS47 (pulp), HS6 (trees and plants), and HS41 (hide and leather). At the low end of the HME statistics, homogenous product industries seem to be appropriately representative for probit estimation.

Our strong support of the home-market effect on a wide range of industries is consistent with the findings of Davis and Weinstein (2003) for OECD countries, although their approach involves relative changes to production and demand. They find strong evidence of home-market effects for a broad segment of manufacturing

[16] Helpman et al. (2008) addresses this issue by using probit estimation in a two-stage estimation.

industries.[17] In addition, Davis and Weinstein (1999) use the same approach as do Davis and Weinstein (2003) for Japanese prefectures. Their findings are less strong than ours; they find evidence of the home-market effect for eight of 19 manufacturing industries. Feenstra et al. (2001) separate differentiated goods from homogeneous goods using Rauch's (1999) measures. They find evidence of a home-market effect in differentiated goods but not in homogeneous goods.

4-3. Estimation Model for Export Share

Hypothesis 2 proposes another empirical prediction. The export share of region 1, located further from the foreign country, declines with respect to an increase in foreign labor. In this subsection, we empirically test this prediction of hypothesis 2.

For hypothesis 2, we need to construct the dependent variable as the export share of the region in total exports. We divided regional exports by the sum of exports from all regions. To determine the effect of the foreign labor force, we need to classify each region as a region-1 type (located relatively further from the foreign country) or a region-2 type (located closer to the foreign country) because the effect has the opposite sign for the two regions. We introduce an indicator function, $f(\tau_{ij})$, which takes a positive value for the region-1 type and a negative value for the region-2 type. Specifically, we implement the specification for an indicator function in which region-specific distance is subtracted from the average distance between two countries. This indicator function is multiplied by the figure for foreign labor. The net effect of foreign labor is then measured by multiplying the estimated coefficient and the indicator function. With this function, Hypothesis 2 implies that the coefficient $\bar{\gamma}_1$ is negative, indicating that the effect of the foreign labor increase is negative for the region-1 type.

In addition, we need to control for the relative size of regions because a large region is likely to have a large export share. Our estimation model for testing hypothesis 2 is given in equation (40),

$$\left(\frac{E_{ijt}}{\sum_{i=1}^{9} E_{ijt}} \right) = \bar{\gamma}_1 f(\tau_{ij}) \times L_{it} + \bar{\gamma}_2 f(\tau_{ij}) \times L_{jt} + \bar{\gamma}^{ij} + \varepsilon_{ijt} \qquad (40)$$

where the second term is also an interaction term of the local region labor variable with the indicator function. In addition, a fixed-effect dummy $\bar{\gamma}_{ij}$ for the control variable is

[17] Head and Ries (2001), on the other hand, find evidence against a home market effect, using sector-level trade between the US and Canada.

introduced.

Table 4 provides estimated coefficients in the regression equation (40). Empirical results overwhelmingly support Hypothesis 2. For 85 industries out of 97, the coefficients of foreign labor are estimated to be negative, 41 of which are statistically significant at the ten percent level. Refreshing the detailed results of numerical simulation, the effect of foreign labor is quite distinct between the skilled and unskilled labor forces. For an increase in skilled workers, numerical analysis indicates that exports of both regions decline. Hypothesis 2 only states that the decline in region 2 is less severe. For foreign unskilled labor, it is more intuitive that exports from region 2 increase, whereas exports from region 1 decline. An increase in foreign demand promotes firms to relocate across regions and shifts export from region 1 to region 2.

Now, we move on to testing Hypothesis 3. Hypothesis 3 states that the degree of HME is larger for region 1 if both $\bar{\gamma}_1 < 0$ & $\bar{\gamma}_2 > 0$ hold. For the test of Hypothesis 3, therefore, we test whether or not these coefficients satisfy the expected sign jointly. There are 32 industries with correct signs for both coefficients simultaneously, 9 of which are statistically significant at ten percent. Hypothesis 3 has only weak support from empirical evidence. However, there is even weaker evidence when we look at the reverse case, in which $\bar{\gamma}_1 > 0$ & $\bar{\gamma}_2 < 0$. There are only six industries for reverse signs jointly and only one of which is statistically significant.

Our approach shares some resemblance with the approach taken in Hanson and Xiang (2004). They use the difference-in-difference approach for treatment industries and control industries and find strong evidence of a home-market effect in a panel of 107 exporting countries and 58 importing countries. Their test of home-market effects is whether or not larger countries export relatively more high-transportation-cost, low-substitution-elasticity goods. Our test of the export share effect is whether or not larger regions export relatively more when regions possess geographical advantage.

5. Discussions and conclusions

In this paper, we introduced a two-country trade model with explicit incorporation of two regions in the home country and one region in the foreign country. Our crucial assumption is that regions are heterogeneous in terms of international trade costs. With this model, we are able to establish a foundation for region-based gravity predictions in which trade between a region in the home country and a region in the foreign country depends on the incomes of both regions and the trade costs between them. Specifically, regarding the relative size of income coefficients, our region-based trade model predicts the home-market effect at a regional level. Interestingly, our theoretical model is explicitly for the first time able to predict a change in the relative regional exports in the home country when foreign market grows.

With Japanese trade data disaggregated in regions, we applied a region-based gravity model for exports of 97 industries from nine Japanese regions to eight Asian countries. First, we found strong support for a region-based home-market effect. For most industries, income coefficients of Japanese region are found to be larger than the income coefficients of importing countries. Second, empirical evidence is also favors the export ratio hypothesis, or relative home-market effect. Our empirical results suggest that proximity to trade partner countries and the recent rapid growth of Asian economies have led regions with relative advantage in geographical location to become export platforms for some industries.

There are several trade models that consider regions within a country besides 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 in which countries are intervals on the line. 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, and thus its direct application to empirical exercises 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. These will remain tasks for our future research.

Appendix:

A1. The conditions on trade and transportation costs

We show the conditions of trade and transportation costs, such that trade occurs between any two regions at equilibrium prices. Because trade occurs, $q_{rs}^{*} > 0\,(r, s = 1,2, and\ F, r \neq s)$. Using these inequalities, we can derive the conditions that exist when intra-national trade occurs in *H*, $q_{12}^{*} > 0$, and $q_{21}^{*} > 0$. Using demand functions, we find that in order for intra-national and international trade to occur at any distribution of skilled workers, the following condition must hold:

$$\tau_H < \tau_{\text{int}\,ra} = \frac{2a}{2b + cN}. \qquad \text{(A-1)}$$

Then, deriving the conditions under which international trade occurs in the same way, we find the following conditions:

$$\max\{\tau_{1F}, \tau_{2F}\} < \tau_{\text{int}\,er} \equiv \frac{2a}{2b + cN}. \qquad \text{(A-2)}$$

In this paper, we focus on the situation in which intra-national and international trade occurs. Therefore, we impose these conditions on trade and transportation costs.

A2. Export functions

$$\begin{aligned} E_1 &= E_1(\lambda | \alpha, \beta, \gamma, \phi, L_F, L_H, A_F, \tau_{1F}, \tau_{2F}) \\ &= \frac{(A_F + L_F)L_H \lambda (L_F \gamma \tau_{1F} - L_H \gamma (1-\lambda) T_1 - 2(\beta-\gamma) T_3 \phi)(L_F \gamma \tau_{1F} + L_H \gamma (T_2 + \lambda T_1) + 2(\beta-\gamma) T_4 \phi)}{4(\beta-\gamma)\phi (L_F \gamma + L_H \gamma + 2(\beta-\gamma)\phi)^2} \end{aligned}$$

$$\begin{aligned} E_2 &= E_2(\lambda | \alpha, \beta, \gamma, \phi, L_F, L_H, A_F, \tau_{1F}, \tau_{2F}) \\ &= \frac{(A_F + L_F)L_H (1-\lambda)(L_F \gamma \tau_{2F} - L_H \gamma \lambda T_1 + 2(\beta-\gamma) T_5 \phi)(L_F \gamma \tau_{2F} + L_H \gamma (2\tau_{2F} + \lambda T_1) + 2(\beta-\gamma) T_6 \phi)}{4(\beta-\gamma)\phi (L_F \gamma + L_H \gamma + 2(\beta-\gamma)\phi)^2} \end{aligned}$$

where $T_1 = \tau_{1F} - \tau_{2F}$, $T_2 = \tau_{1F} + \tau_{2F}$, $T_3 = \alpha - \tau_{1F}$, $T_4 = \alpha + \tau_{1F}$, $T_5 = \alpha - \tau_{2F}$, and $T_6 = \alpha + \tau_{2F}$.

A3. The effect of trade cost on regional export

We show the effects of the change in international trade costs between region 1 and country *F* on the price and the amount of export of varieties traded between them.

$$\frac{\partial p_{1F}^*}{\partial \tau_{1F}} = \frac{\partial p_{FF}^*}{\partial \tau_{1F}} + \frac{1}{2} = \left(\frac{cn_1^*}{2b+cN} + \frac{1}{2} \right) + \frac{cn_H (\tau_{1F} - \tau_{2F})}{2b+cN} \frac{\partial \lambda^*}{\partial \tau_{1F}}. \qquad \text{(A-3)}$$

and

$$\frac{\partial q_{1F}^*}{\partial \tau_{1F}} = \frac{\partial q_{FF}^*}{\partial \tau_{1F}} - \frac{b+cN}{2} = \left[\frac{c^2 n_1^* N}{2(2b+cN)} - \frac{(b+cN)}{2} \right] + \frac{c^2 n_H N(\tau_{1F} - \tau_{2F})}{2(2b+cN)} \frac{\partial \lambda^*}{\partial \tau_{1F}}. \qquad \text{(A-4)}$$

The first term in (A-3) is the direct effect on the price, which is found to be positive. The second term in (A-3) is the indirect effect through the migration of skilled workers. The coefficient of $\partial \lambda^* / \partial \tau_{1F}$ is positive from the assumption for international trade costs. As for demand, the first term in (A-4) is the direct effect, which is found to be negative. The second term in (A-4) is the indirect effect through migration of skilled workers. The coefficient of $\partial \lambda^* / \partial \tau_{1F}$ is positive. Because the sign of $\partial \lambda^* / \partial \tau_{1F}$ cannot be derived analytically, the signs of these effects cannot be acquired analytically.

A4. The cross effect of trade cost on regional export

The effect of the change in trade costs between region 2 and country *F* on the price and the amount of varieties traded between region 1 and country *F* is

$$\frac{\partial p_{1F}^*}{\partial \tau_{2F}} = \frac{\partial p_{FF}^*}{\partial \tau_{2F}} = \frac{cn_2^*}{2b+cN} + \frac{cn_H (\tau_{1F} - \tau_{2F})}{2b+cN} \frac{\partial \lambda^*}{\partial \tau_{2F}}, \qquad \text{(A-5)}$$

and

$$\frac{\partial q_{1F}^*}{\partial \tau_{2F}} = \frac{\partial q_{FF}^*}{\partial \tau_{2F}} = \frac{c^2 n_2^* N}{2(2b+cN)} + \frac{c^2 n_H N(\tau_{1F} - \tau_{2F})}{2(2b+cN)} \frac{\partial \lambda^*}{\partial \tau_{2F}}. \qquad \text{(A-6)}$$

Both the price and the exports have direct and indirect effects. The effect on the individual value of exports from region 1 to country *F* is therefore represented as follows:

$$\frac{\partial p_{1F}^* q_{1F}^*}{\partial \tau_{2F}} = \frac{cn_1^* (2q_{1F}^* + cNp_{1F}^*)}{2(2b+cN)} + \frac{cn_H (\tau_{1F} - \tau_{2F})(2q_{1F}^* + cNp_{1F}^*) \frac{\partial \lambda^*}{\partial \tau_{2F}}}{2(2b+cN)}. \qquad \text{(A-7)}$$

The effect of the change in trade costs on the exports of region 1 has direct and indirect effects. It is clear that the direct effects of the changes in international trade costs between region 2 and country *F* on the value of exports from region 1 are positive. Moreover, the coefficients of $\partial \lambda^* / \partial \tau_{2F}$ are positive. However, the sign of the indirect effects cannot be derived analytically because it might be impossible for the sign of $\partial E_{1F} / \partial \tau_{2F}$ to be found analytically.

A5. 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.

A6. 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・and spices.
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

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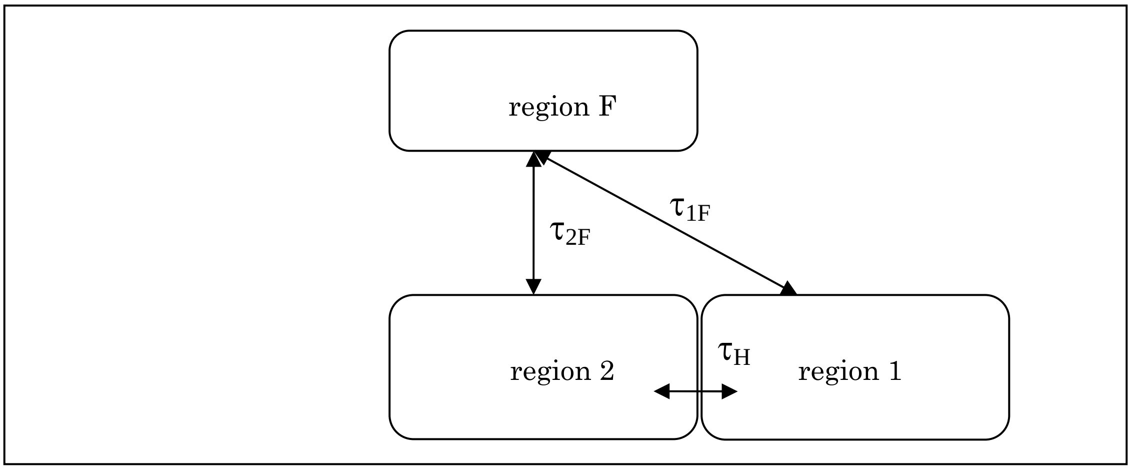
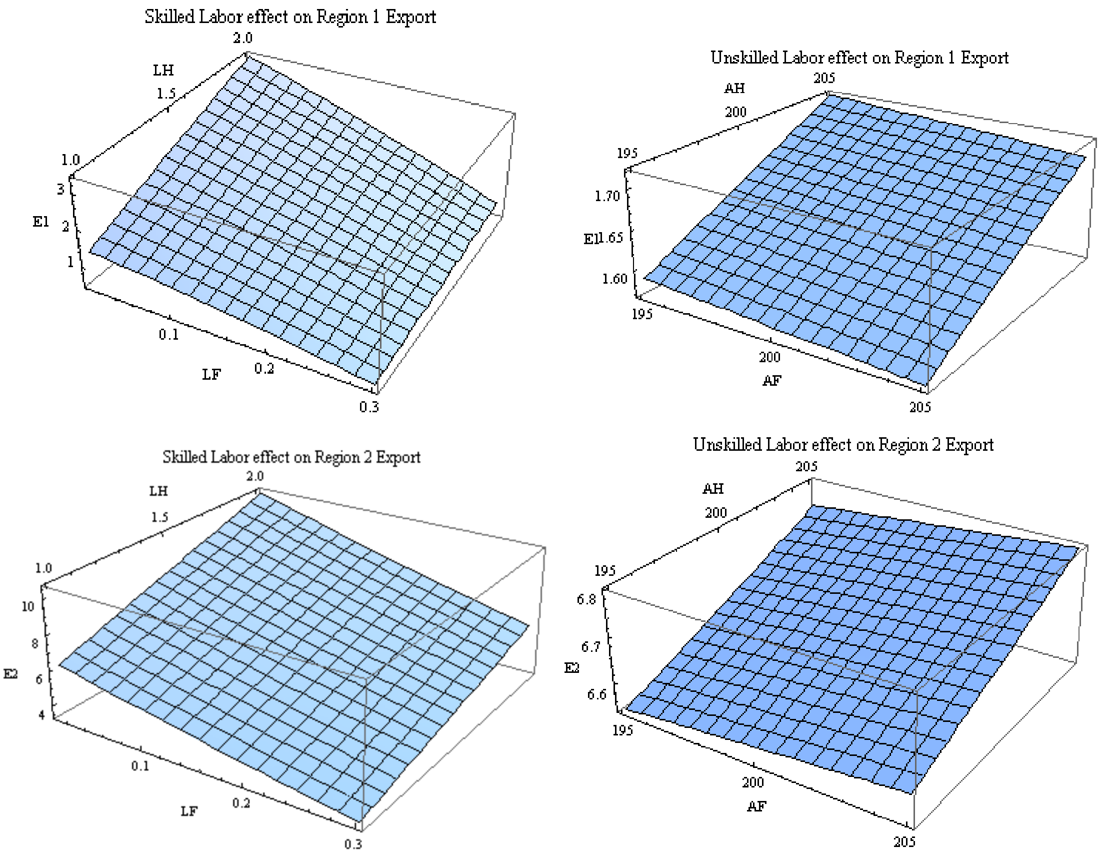
Figure 1. The geography of the two home region and one foreign region model



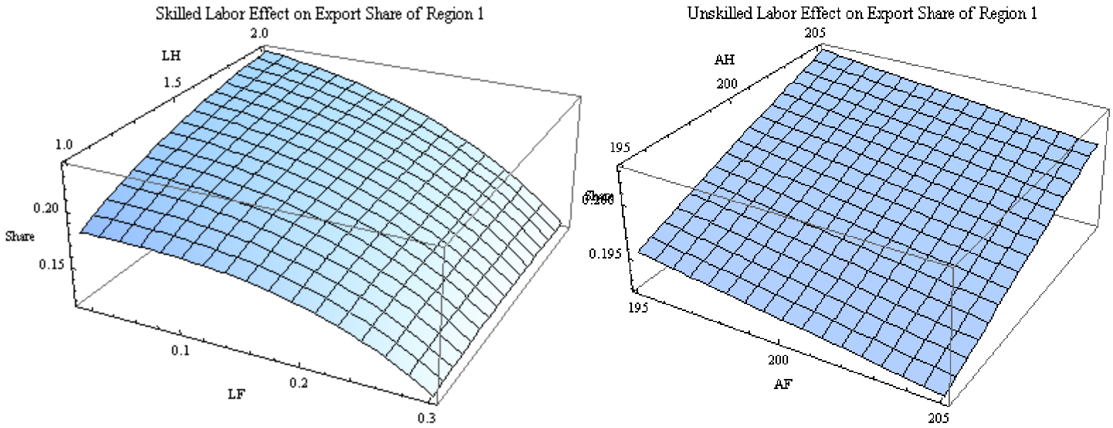
Note: Regions 1 and 2 represent the Home country and region F is a foreign country. International trade costs are represented by the length of arrows between two regions.

Figure 2. The Effect of Labor Size on Regional Exports



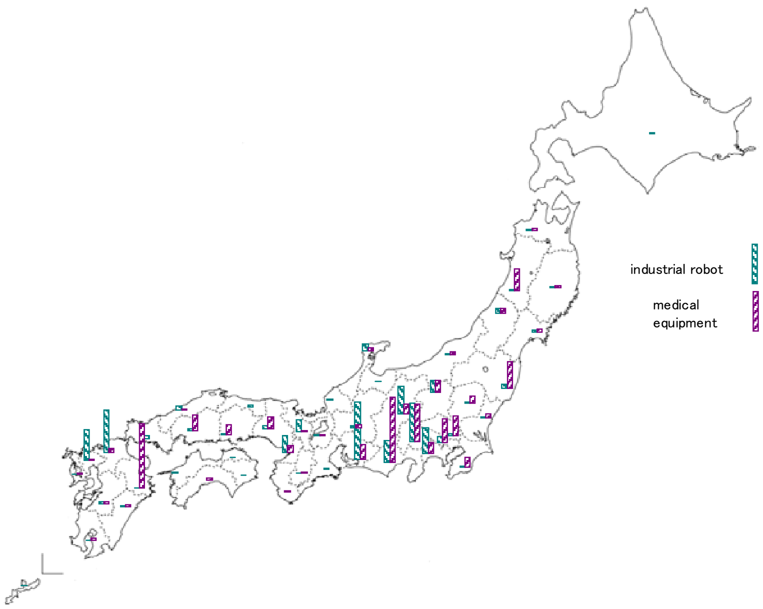
Note: Baseline parameter values of $\theta = (\alpha, \beta, \gamma, \phi, L_F, L_H, A_F, A_H, \tau_{1F}, \tau_{2F,} \tau_H)$ are (5, 2, 1, 10, 0.15, 1.5, 200, 200, 4.9, 4.8, 2).

Figure 3. The Effect of Labor Size on Export Share



Note: Baseline parameter values of $\theta = (\alpha, \beta, \gamma, \phi, L_F, L_H, A_F, A_H, \tau_{1F}, \tau_{2F,} \tau_H)$ are (5, 2, 1, 10, 0.15, 1.5, 200, 200, 4.9, 4.8, 2).

Figure 4. Regional production in 2005:
Industrial robot [JSIC2698] and medical equipment [JSIC3131]



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

Table 1. The Effect of the Labor Force on Regional Exports and Export Share

type of labor	Region1 export	Region 2 export	Export Share
L_F	-	-	-
A_F	-	+	-
L_H	+	+	?
A_H	+	+	+

Note: Baseline parameter values of $\theta = (\alpha, \beta, \gamma, \phi, L_F, L_H, A_F, A_H, \tau_{1F}, \tau_{2F,} \tau_H)$ are (5, 2, 1, 10, 0.15, 1.5, 200, 200, 4.9, 4.8, 2).

Table 2. Least Square Estimates and HME Test Statistics

(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2
(10)Cereals.	0.28992 (0.34676)	4.352*** (0.91652)	-102760*** (25626)	3.77	0.047
(8)Edible fruit and nuts; peel of citrus fruit or melons.	4.8458 (6.9921)	78.68*** (18.48)	-1914500*** (516720)	3.40	0.023
(24)Tobacco and manufactured tobacco substitutes.	19.851 (24.635)	278.71*** (65.113)	-6630200*** (1820600)	3.38	0.022
(2)Meat and edible meat offal.	0.37708 (0.40095)	4.2912*** (1.0597)	-107050*** (29630)	3.14	0.024
(11)Prod mill indust; malt; starches; inulin; wheat gluten	5.4295 (6.1244)	64.961*** (16.187)	-1630900*** (452600)	3.13	0.023
(79)Zinc and articles thereof.	27.201 (17.642)	192.25*** (46.628)	-5067900*** (1303700)	3.01	0.025
(16)Prep of meat, fish or crustaceans, molluscs etc	48.623 (32.384)	344.39*** (85.592)	-9049300*** (2393200)	2.94	0.024
(42)Articles of leather; saddlery/harness; travel goods etc	6.9859* (4.1145)	44.107*** (10.875)	-1179000*** (304060)	2.91	0.024
(86)Railw/tramw locom, rolling-stock & parts thereof; etc	138.02* (78.261)	834.33*** (206.85)	-22773000*** (5783500)	2.87	0.023
(19)Prep of cereal, flour, starch/milk; pastrycooks' prod	20.987* (11.636)	124.03*** (30.755)	-3358300*** (859910)	2.85	0.025
(22)Beverages, spirits and vinegar.	19.139** (9.5717)	103.56*** (25.299)	-2830700*** (707350)	2.84	0.025
(89)Ships, boats and floating structures.	256.55* (155.05)	1619.7*** (409.82)	-43209000*** (11459000)	2.83	0.027
(7)Edible vegetables and certain roots and tubers.	2.809 (2.5474)	25.106*** (6.7329)	-664040*** (188250)	2.82	0.022
(91)Clocks and watches and parts thereof.	111.15 (84.176)	847.44*** (222.48)	-22437000*** (6220700)	2.82	0.024
(45)Cork and articles of cork.	0.26866* (0.14931)	1.5552*** (0.39464)	-42070*** (11034)	2.77	0.026
(71)Natural/cultured pearls, prec stones & metals, coin etc	613.23** (304.7)	3217*** (805.34)	-88744000*** (22517000)	2.75	0.026
(41)Raw hides and skins (other than furskins) and leather.	43.52** (21.495)	227.05*** (56.813)	-6163700*** (1588500)	2.75	0.024
(4)Dairy prod; birds' eggs; natural honey; edible prod nes	2.0074** (0.9581)	10.15*** (2.5323)	-282740*** (70804)	2.74	0.025
(88)Aircraft, spacecraft, and parts thereof.	5.6849** (2.6369)	28.079*** (6.9696)	-778410*** (194870)	2.73	0.027
(18)Cocoa and cocoa preparations.	9.2962** (3.9059)	42.143*** (10.323)	-1167800*** (288640)	2.71	0.026
(64)Footwear, gaiters and the like; parts of such articles.	12.16** (5.1928)	55.487*** (13.725)	-1552900*** (383750)	2.69	0.027
(80)Tin and articles thereof.	22.606** (8.9199)	95.175*** (23.576)	-2723200*** (659180)	2.62	0.028
(62)Art of apparel & clothing access, not knitted/crocheted	35.01*** (13.276)	141.47*** (35.089)	-4093300*** (981080)	2.58	0.027
(61)Art of apparel & clothing access, knitted or crocheted.	33.537*** (12.658)	133.81*** (33.455)	-3852700*** (935400)	2.55	0.027

(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2
(63)other made up textile articles; sets; worn clothing etc	23.913*** (9.2648)	96.372*** (24.488)	-2800400*** (684680)	2.52	0.028
(96)Miscellaneous manufactured articles.	161.8*** (61.802)	642.67*** (163.35)	-18953000*** (4567200)	2.51	0.027
(60)Knitted or crocheted fabrics.	155.49*** (57.432)	593.64*** (151.8)	-17925000*** (4244300)	2.46	0.027
(20)Prep of vegetable, fruit, nuts or other parts of plants	6.9094*** (2.2931)	24.281*** (6.0607)	-714040*** (169460)	2.44	0.029
(56)Wadding, felt & nonwoven; yarns; twine, cordage, etc	139.04*** (49.132)	507.31*** (129.86)	-15145000*** (3630900)	2.41	0.028
(59)Impregnated, coated, cover/laminated textile fabric etc	150.6*** (52.853)	546.51*** (139.69)	-16469000*** (3905900)	2.41	0.028
(5)Products of animal origin, nes or included.	4.8498*** (1.8003)	18.31*** (4.7584)	-536750*** (133040)	2.41	0.026
(36)Explosives; pyrotechnic prod; matches; pyrop alloy; etc	1.0009** (0.45054)	4.3653*** (1.1908)	-126790*** (33295)	2.40	0.026
(85)Electrical mchy equip parts thereof; sound recorder etc	22826*** (7413.8)	76495*** (19595)	-2328100000*** (547880000)	2.33	0.029
(48)Paper & paperboard; art of paper pulp, paper/paperboard	460.27*** (152.42)	1560.9*** (402.86)	-47270000*** (11264000)	2.33	0.029
(54)Man-made filaments.	431.82*** (141.39)	1448.1*** (373.71)	-44623000*** (10449000)	2.31	0.029
(52)Cotton.	242.63*** (83.009)	836.51*** (219.4)	-26105000*** (6134400)	2.30	0.029
(78)Lead and articles thereof.	7.3745*** (2.2181)	23.165*** (5.8626)	-703460*** (163920)	2.29	0.030
(95)Toys, games & sports requisites; parts & access thereof	309.77*** (93.595)	974.31*** (247.38)	-29680000*** (6916700)	2.29	0.031
(9)Coffee, tea, mat・and spices.	5.0514*** (1.5997)	16.362*** (4.2282)	-503650*** (118220)	2.28	0.030
(81)other base metals; cermets; articles thereof.	293.24*** (88.549)	915.06*** (234.04)	-28077000*** (6543800)	2.26	0.030
(57)Carpets and other textile floor coverings.	5.5005*** (1.8425)	18.39*** (4.8698)	-569270*** (136160)	2.25	0.028
(76)Aluminium and articles thereof.	586.21*** (177.42)	1825.7*** (468.94)	-56568000*** (13112000)	2.25	0.031
(68)Art of stone, plaster, cement, asbestos, mica/sim mat	264.13*** (77.678)	803.54*** (205.31)	-24559000*** (5740500)	2.24	0.031
(83)Miscellaneous articles of base metal.	155.39*** (48.016)	488.36*** (126.91)	-15319000*** (3548400)	2.23	0.030
(58)Special woven fab; tufted tex fab; lace; tapestries etc	77.87*** (23.68)	241.5*** (62.587)	-7690500*** (1749900)	2.23	0.030
(51)Wool, fine/coarse animal hair, horsehair yarn & fabric	110.95*** (34.744)	350.68*** (91.831)	-11240000*** (2567600)	2.22	0.030
(55)Man-made staple fibres.	275.96*** (86.363)	868.16*** (228.26)	-27536000*** (6382300)	2.21	0.030
(35)Albuminoidal subs; modified starches; glues; enzymes.	159.44*** (45.017)	468.08*** (118.98)	-14472000*** (3326800)	2.21	0.032

Note: For expository purpose, coefficients for GDPIM and GDPR are presented after original estimated coefficients are multiplied by 1,000,000. Figures in parenthesis are heteroskedastic consistent standard errors. *, **, *** denote statistical significance at ten, five, and one percent level, respectively. HME test represents statistics given in equation (31) and critical value for ten percent significance level is 1.282.

Table 2(continued). Least Square Estimates and HME Test Statistics

(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2
(21)Miscellaneous edible preparations.	106.62*** (29.95)	311.07*** (79.159)	-9671700*** (2213300)	2.20	0.032
(46)Manufactures of straw, esparto/other plaiting mat; etc	0.18253*** (0.060437)	0.59473*** (0.15974)	-18462*** (4466.3)	2.20	0.028
(47)Pulp of wood/of other fibrous cellulosic mat; waste etc	205.11*** (60.299)	611.07*** (159.38)	-19630000*** (4456200)	2.17	0.030
(53)other vegetable textile fibres; paper yarn & woven fab	11.288*** (3.5495)	34.945*** (9.3816)	-1121200*** (262310)	2.15	0.028
(17)Sugars and sugar confectionery.	20.465*** (5.4645)	56.778*** (14.443)	-1746000*** (403830)	2.14	0.033
(37)Photographic or cinematographic goods.	904.41*** (247.71)	2546.6*** (654.7)	-79822000*** (18306000)	2.13	0.032
(6)Live tree & other plant; bulb, root; cut flowers etc	6.231*** (1.8902)	18.732*** (4.9958)	-601200*** (139680)	2.13	0.029
(65)Headgear and parts thereof.	2.8447*** (0.77654)	7.9682*** (2.0525)	-248670*** (57387)	2.12	0.032
(33)Essential oils & resinoids; perf, cosmetic/toilet prep	285.3*** (76.623)	790.05*** (202.52)	-24639000*** (5662500)	2.12	0.032
(40)Rubber and articles thereof.	820.59*** (230.71)	2332.9*** (609.77)	-74354000*** (17049000)	2.11	0.032
(66)Umbrellas, walking-sticks, seat-sticks, whips, etc	0.25997*** (0.099362)	0.90868*** (0.26262)	-26142*** (7342.9)	2.10	0.027
(82)Tool, implement, cutlery, spoon & fork, of base met etc	497.21*** (138.25)	1395.5*** (365.4)	-44793000*** (10217000)	2.09	0.032
(73)Articles of iron or steel.	1460.5*** (426.56)	4223.4*** (1127.4)	-135010000*** (31523000)	2.09	0.031
(32)Tanning/dyeing extract; tannins & derivs; pigm etc	888.73*** (240.42)	2445.1*** (635.45)	-77985000*** (17767000)	2.08	0.032
(74)Copper and articles thereof.	2126*** (591.53)	5941.4*** (1563.5)	-191150000*** (43715000)	2.08	0.031
(39)Plastics and articles thereof.	5573.3*** (1504.1)	15244*** (3975.5)	-489940000*** (111150000)	2.07	0.032
(84)Nuclear reactors, boilers, mchy & mech appliance; parts	20329*** (5480.1)	55327*** (14484)	- 1778500000***	2.06	0.032
(69)Ceramic products.	199.37*** (52.363)	532.1*** (138.4)	-16594000*** (3869700)	2.05	0.034
(90)optical, photo, cine, meas, checking, precision, etc	7858.8*** (2062)	20930*** (5450)	-674600000*** (152380000)	2.04	0.033
(87)Vehicles o/t railw/tramw roll-stock, pts & accessories	4998.1*** (1383.9)	13732*** (3657.7)	-447160000*** (102270000)	2.03	0.032
(44)Wood and articles of wood; wood charcoal.	20.207*** (5.2833)	53.149*** (13.964)	-1685000*** (390440)	2.01	0.033
(31)Fertilizers.	11.354*** (4.0793)	36.346*** (10.782)	-1127300*** (301470)	1.97	0.034
(38)Miscellaneous chemical products.	2743.2*** (677.58)	6832.5*** (1790.9)	-222580000*** (50074000)	1.94	0.034
(34)Soap, organic surface-active agents, washing prep, etc	408.74*** (101.68)	1019*** (268.74)	-33250000*** (7514000)	1.93	0.034

(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2
(28)Inorgn chem; compds of prec met, radioact elements etc	975.12*** (244.43)	2440.7*** (646.04)	-79473000*** (18063000)	1.93	0.034
(92)Musical instruments; parts and access of such articles	43.935*** (11.397)	112.19*** (30.123)	-3696400*** (842250)	1.93	0.036
(3)Fish & crustacean, mollusc & other aquatic invertebrate	306.07*** (73.908)	745.45*** (195.34)	-24033000*** (5461900)	1.91	0.034
(97)Works of art, collectors' pieces and antiques.	6.7409*** (1.5894)	15.971*** (4.2009)	-521230*** (117460)	1.87	0.035
(30)Pharmaceutical products.	199.99*** (46.291)	461.49*** (122.35)	-15421000*** (3420900)	1.82	0.036
(12)oil seed, oleagi fruits; miscell grain, seed, fruit etc	25.359*** (5.8747)	57.943*** (15.527)	-1926000*** (434140)	1.79	0.035
(70)Glass and glassware.	1507.4*** (338.73)	3359.3*** (895.3)	-113110000*** (25033000)	1.76	0.036
(15)Animal/veg fats & oils & their cleavage products; etc	15.468*** (3.4402)	33.747*** (9.0926)	-1108500*** (254230)	1.71	0.037
(67)Prepr feathers & down; arti flower; articles human hair	1.3066*** (0.28416)	2.7818*** (0.75105)	-97075*** (20999)	1.67	0.038
(49)Printed books, newspapers, pictures & other product etc	160.49*** (35.71)	341.64*** (94.385)	-11954000*** (2639000)	1.63	0.036
(26)ores, slag and ash.	38.783*** (8.212)	80.209*** (21.705)	-2740300*** (606870)	1.62	0.038
(13)Lac; gums, resins & other vegetable saps & extracts.	8.8347*** (1.734)	17.543*** (4.583)	-578940*** (128140)	1.62	0.042
(94)Furniture; bedding, mattress, matt support, cushion etc	196.21*** (43.388)	405.68*** (114.68)	-14674000*** (3206400)	1.55	0.037
(14)Vegetable plaiting materials; vegetable products nes	0.34279*** (0.083889)	0.74172*** (0.22172)	-21482*** (6199.4)	1.53	0.029
(29)organic chemicals.	6345.2*** (1315.2)	12583*** (3476.1)	-446910000*** (97193000)	1.53	0.038
(27)Mineral fuels, oils & product of their distillation; etc	1740.5*** (358.9)	3430.4*** (948.59)	-122130000*** (26523000)	1.52	0.038
(25)Salt; sulphur; earth & ston; plastering mat; lime & cem	173.56*** (35.454)	339.17*** (93.707)	-11976000*** (2620100)	1.50	0.040
(72)Iron and steel.	10715*** (2149.2)	20593*** (5680.4)	-726050000*** (158830000)	1.48	0.040
(23)Residues & waste from the food indust; prepr ani fodder	26.072*** (4.8963)	46.72*** (12.941)	-1592300*** (361840)	1.36	0.042
(43)Furskins and artificial fur; manufactures thereof.	0.35125*** (0.12551)	0.86631*** (0.33173)	-31225*** (9275.1)	1.32	0.029
(93)Arms and ammunition; parts and accessories thereof.	0.063405*** (0.014129)	0.11457*** (0.037344)	-3955.4*** (1044.1)	1.17	0.045
(75)Nickel and articles thereof.	198.4*** (33.074)	313.38*** (87.416)	-11619000*** (2444200)	1.12	0.049
(50)Silk.	30.363*** (5.7777)	49.987*** (15.271)	-2022100*** (426970)	1.09	0.041
(1)Live animals.	3.1794*** (0.46937)	4.367*** (1.2406)	-165880*** (34686)	0.81	0.056

Note: For expository purpose, coefficients for GDPIM and GDPR are presented after original estimated coefficients are multiplied by 1,000,000. Figures in parenthesis are heteroskedastic consistent standard errors. *, **, *** denote statistical significance at ten, five, and one percent level, respectively. HME test represents statistics given in equation (31) and critical value for ten percent significance level is 1.282.

Table 3. Probit Estimates and HME Test Statistics

(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2	(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2
(37)Photographic or cinematographic goods.	-4.3001***	23.628***	-0.00045945***	16.07	0.640	(45)Cork and articles of cork.	-4.6389***	7.527***	-0.00036374***	13.11	0.239
	(0.88003)	(1.275)	(0.000024016)				(0.73257)	(0.41996)	(0.000017928)		
(30)Pharmaceutical products.	-4.258***	17.009***	-0.00035491***	15.90	0.529	(62)Art of apparel & clothing access, not knitted/crocheted	1.8177*	24.56***	-0.00050805***	12.90	0.665
	(0.81153)	(0.87524)	(0.000019823)				(0.96632)	(1.3342)	(0.000025812)		
(92)Musical instruments; parts and access of such articles	-2.9717***	18.701***	-0.00044946***	15.65	0.593	(59)Impregnated, coated, cover/laminated textile fabric etc	-0.91034	24.623***	-0.0003715***	12.84	0.567
	(0.80554)	(0.96419)	(0.000022335)				(0.92925)	(1.512)	(0.000022567)		
(78)Lead and articles thereof.	-3.101***	16.127***	-0.00041647***	15.01	0.548	(38)Miscellaneous chemical products.	-0.2149	41.226***	-0.00031403***	12.84	0.498
	(0.8089)	(0.82622)	(0.000020819)				(1.1972)	(2.7178)	(0.000026944)		
(33)Essential oils & resinoids; perf, cosmetic/toilet prep	-1.9281**	18.837***	-0.0004045***	14.45	0.568	(28)Inorgn chem; compds of prec met, radioact elements etc	-0.53682	39.01***	-0.00029091***	12.78	0.460
	(0.83562)	(0.99857)	(0.000021508)				(1.1598)	(2.5806)	(0.000026113)		
(88)Aircraft, spacecraft, and parts thereof.	-5.0418***	9.8337***	-0.00039148***	14.42	0.364	(52)Cotton.	1.767*	21.485***	-0.00050175***	12.77	0.644
	(0.76868)	(0.52288)	(0.000019211)				(0.91861)	(1.1315)	(0.000025091)		
(91)Clocks and watches and parts thereof.	-2.0723**	21.942***	-0.00041144***	14.39	0.594	(96)Miscellaneous manufactured articles.	-0.086412	30.445***	-0.00036904***	12.40	0.554
	(0.88085)	(1.2189)	(0.000022327)				(1.0334)	(1.9487)	(0.00002437)		
(13)Lac; gums, resins & other vegetable saps & extracts.	-1.8917**	15.647***	-0.00047145***	14.32	0.557	(40)Rubber and articles thereof.	-0.72882	39.547***	-0.00024245***	12.31	0.428
	(0.80079)	(0.79369)	(0.000023098)				(1.1765)	(2.7465)	(0.000026409)		
(69)Ceramic products.	-3.5949***	29.663***	-0.00041071***	14.12	0.605	(15)Animal/veg fats & oils & their cleavage products; etc	0.2166	15.975***	-0.00038606***	12.23	0.533
	(0.94939)	(1.8488)	(0.00002499)				(0.83035)	(0.85006)	(0.000020067)		
(75)Nickel and articles thereof.	-1.5122*	18.116***	-0.00035778***	13.86	0.541	(49)Printed books, newspapers, pictures & other product etc	0.27345	29.04***	-0.00035394***	12.08	0.541
	(0.84708)	(0.96301)	(0.000019751)				(1.0251)	(1.8849)	(0.00002389)		
(81)other base metals; cermets; articles thereof.	-0.31972	23.573***	-0.0004231***	13.77	0.614	(61)Art of apparel & clothing access, knitted or crocheted.	1.9053**	19.028***	-0.00044532***	11.99	0.599
	(0.91547)	(1.2933)	(0.000022963)				(0.90353)	(0.99414)	(0.000022724)		
(79)Zinc and articles thereof.	-1.8517**	16.452***	-0.00032594***	13.74	0.504	(64)Footwear, gaiters and the like; parts of such articles.	0.84711	17.335***	-0.00036122***	11.98	0.532
	(0.81074)	(0.88216)	(0.000018887)				(0.87576)	(0.92539)	(0.000019901)		
(71)Natural/cultured pearls, prec stones & metals, coin etc	-1.9401**	22.737***	-0.00036437***	13.74	0.568	(74)Copper and articles thereof.	3.3585**	40.16***	-0.00038463***	11.81	0.548
	(0.88916)	(1.3348)	(0.000021482)				(1.3731)	(2.551)	(0.000027562)		
(42)Articles of leather; saddlery/harness; travel goods etc	-0.38199	18.376***	-0.00043028***	13.65	0.583	(18)Cocoa and cocoa preparations.	-3.2571***	7.5488***	-0.00034786***	11.74	0.273
	(0.84591)	(0.94986)	(0.000021998)				(0.72947)	(0.42788)	(0.000017372)		
(58)Special woven fab; tufted tex fab; lace; tapestries etc	0.34696	22.42***	-0.00049319***	13.64	0.644	(29)organic chemicals.	0.43959	33.05***	-0.00025775***	11.61	0.426
	(0.89848)	(1.1971)	(0.000024896)				(1.1419)	(2.279)	(0.000024394)		
(80)Tin and articles thereof.	-2.1859***	13.355***	-0.00040313***	13.56	0.496	(32)Tanning/dyeing extract; tannins & derivs; pigm etc	0.23254	29.746***	-0.00026926***	11.41	0.459
	(0.78109)	(0.68789)	(0.000020183)				(1.0715)	(2.0635)	(0.000023366)		
(68)Art of stone, plaster, cement, asbestos, mica/sim mat	-0.9717	42.805***	-0.00035987***	13.54	0.530	(9)Coffee, tea, mat・and spices.	-1.0878	10.397***	-0.0003688***	11.29	0.412
	(1.1664)	(2.7172)	(0.000027484)				(0.75622)	(0.5531)	(0.000018373)		
(65)Headgear and parts thereof.	-2.8619***	11.391***	-0.00040712***	13.50	0.447	(34)Soap, organic surface-active agents, washing prep, etc	1.1045	27.951***	-0.00032318***	11.28	0.511
	(0.75975)	(0.59285)	(0.000019964)				(1.0718)	(1.8456)	(0.000023134)		
(82)Tool, implement, cutlery, spoon & fork, of base met etc	-0.63069	43.837***	-0.00035015***	13.43	0.527	(35)Albuminoidal subs; modified starches; glues; enzymes.	0.87845	26.883***	-0.00031129***	11.14	0.508
	(1.2013)	(2.793)	(0.000027761)				(1.0499)	(1.8208)	(0.000022813)		
(60)Knitted or crocheted fabrics.	0.98801	21.657***	-0.00051202***	13.37	0.655	(90)optical, photo, cine, meas, checking, precision, etc	4.0725**	48.826***	-0.00033087***	11.12	0.471
	(0.90343)	(1.13)	(0.000024931)				(1.6343)	(3.4903)	(0.000031017)		
(70)Glass and glassware.	-1.5544	32.094***	-0.00032427***	13.36	0.527	(94)Furniture; bedding, mattress, matt support, cushion etc	1.3897	28.806***	-0.00031654***	11.04	0.503
	(0.98102)	(2.0415)	(0.000023952)				(1.0992)	(1.9525)	(0.00002347)		
(11)Prod mill indust; malt; starches; inulin; wheat gluten	-1.3641*	14.22***	-0.00037645***	13.34	0.515	(17)Sugars and sugar confectionery.	-0.14816	12.829***	-0.00031491***	10.99	0.446
	(0.7843)	(0.72116)	(0.000019425)				(0.80472)	(0.71585)	(0.000017614)		
(57)Carpets and other textile floor coverings.	-1.8325**	13.19***	-0.00038493***	13.27	0.481	(73)Articles of iron or steel.	1.7948	48.578***	-0.00022446***	10.97	0.380
	(0.76588)	(0.689)	(0.000019598)				(1.4917)	(3.778)	(0.000031521)		
(83)Miscellaneous articles of base metal.	-0.71507	34.746***	-0.00036449***	13.18	0.549	(19)Prep of cereal, flour, starch/milk; pastrycooks' prod	0.2689	14.199***	-0.00030644***	10.96	0.460
	(1.0571)	(2.1822)	(0.000025362)				(0.8337)	(0.79884)	(0.000017936)		

Note: For expository purpose, coefficients for GDPIM and GDPR are presented after original estimated coefficients are multiplied by 1,000,000,000,000,000. Figures in parenthesis are heteroskedastic consistent standard errors. *, **, *** denote statistical significance at ten, five, and one percent level, respectively. HME test represents statistics given in equation (31) and critical value for ten percent significance level is 1.282.

Table 3(continued). Probit Estimates and HME Test Statistics

(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2
(86)Railw/tramw locom, rolling-stock & parts thereof; etc	-0.26789	11.627***	-0.00033356***	10.93	0.435
	(0.77684)	(0.63556)	(0.000017952)		
(36)Explosives; pyrotechnic prod; matches; pyrop alloy; etc	-3.7785***	6.0788***	-0.00036283***	10.87	0.166
	(0.73131)	(0.3907)	(0.000017718)		
(55)Man-made staple fibres.	1.0581	19.171***	-0.00029291***	10.85	0.482
	(0.92843)	(1.1959)	(0.000019529)		
(67)Prepr feathers & down; arti flower; articles human hair	-2.0372***	7.7787***	-0.00039179***	10.79	0.295
	(0.71794)	(0.44283)	(0.000018786)		
(76)Aluminium and articles thereof.	3.3421***	33.04***	-0.00035278***	10.73	0.538
	(1.278)	(2.1911)	(0.000025399)		
(56)Wadding, felt & nonwoven; yarns; twine, cordage, etc	2.764**	28.406***	-0.00035069***	10.48	0.529
	(1.1502)	(1.9116)	(0.0000239)		
(54)Man-made filaments.	2.6639***	22.646***	-0.00035401***	10.37	0.541
	(1.0304)	(1.4329)	(0.000021857)		
(48)Paper & paperboard; art of paper pulp, paper/paperboard	1.7699	37.525***	-0.00015482***	10.35	0.358
	(1.3829)	(2.8994)	(0.000027425)		
(95)Toys, games & sports requisites; parts & access thereof	3.4949***	25.048***	-0.00040034***	10.26	0.583
	(1.0977)	(1.5816)	(0.000023587)		
(24)Tobacco and manufactured tobacco substitutes.	-3.072***	6.2188***	-0.00042684	10.21	0.197
	(0.72791)	(0.4054)	(0.000019989)		
(20)Prep of vegetable, fruit, nuts or other parts of plants	0.98811	12.697***	-0.00034613***	10.03	0.464
	(0.81658)	(0.69928)	(0.000018606)		
(39)Plastics and articles thereof.	3.8287**	44.065***	-0.00022313***	9.91	0.378
	(1.6629)	(3.4438)	(0.000030007)		
(63)other made up textile articles; sets; worn clothing etc	2.2054**	20.454***	-0.00027285***	9.72	0.473
	(1.018)	(1.3569)	(0.000019839)		
(46)Manufactures of straw, esparto/other plaiting mat; etc	-1.2726*	7.4905***	-0.00039797***	9.72	0.295
	(0.72293)	(0.42901)	(0.00001882)		
(4)Dairy prod; birds' eggs; natural honey; edible prod nes	-1.4667**	6.9827***	-0.00034636***	9.53	0.253
	(0.71125)	(0.40966)	(0.00001715)		
(85)Electrical mchy equip parts thereof; sound recorder etc	3.0625	63.494***	-0.00019981***	9.39	0.323
	(1.8663)	(5.9518)	(0.000038992)		
(97)Works of art, collectors' pieces and antiques.	-0.52926	7.818***	-0.00041116	9.19	0.327
	(0.72872)	(0.44319)	(0.000019245)		
(31)Fertilizers.	-0.94913	7.9491***	-0.00014432***	9.06	0.255
	(0.73858)	(0.5038)	(0.00001435)		
(22)Beverages, spirits and vinegar.	2.227***	13.048***	-0.00033819***	8.97	0.469
	(0.85469)	(0.72846)	(0.000018542)		
(2)Meat and edible meat offal.	-2.5829***	5.2189***	-0.00035161***	8.90	0.162
	(0.70819)	(0.37598)	(0.000017337)		
(16)Prep of meat, fish or crustaceans, molluscs etc	1.0021	10.923***	-0.00026377***	8.74	0.385
	(0.8107)	(0.64347)	(0.00001655)		
(93)Arms and ammunition; parts and accessories thereof.	-3.9767***	3.5374***	-0.00034411***	8.35	0.030
	(0.73491)	(0.36121)	(0.00001756)		
(87)Vehicles o/t railw/tramw roll-stock, pts & accessories	2.0429	26.512***	-	8.35	0.233
	(1.2771)	(2.297)	0.000067858**		
(8)Edible fruit and nuts; peel of citrus fruit or melons.	-1.8716***	5.1478***	-0.00026252***	8.34	0.162
	(0.68099)	(0.35889)	(0.000015089)		

(HS2) Industry	GDPIM	GDPR	Distance	HMEtest	adj. R2
(7)Edible vegetables and certain roots and tubers.	0.34026	8.0321***	-0.00032475***	8.28	0.320
	(0.73573)	(0.45777)	(0.000016812)		
(23)Residues & waste from the food indust; prepr ani fodder	1.6735*	12.834***	-0.00017965***	8.22	0.363
	(0.88876)	(0.84378)	(0.000016365)		
(14)Vegetable plaiting materials; vegetable products nes	-0.44256	6.8178***	-0.00038545***	8.22	0.263
	(0.71773)	(0.40893)	(0.0000184)		
(50)Silk.	1.5283**	9.2415***	-0.00043352***	8.11	0.415
	(0.76794)	(0.49386)	(0.000020397)		
(21)Miscellaneous edible preparations.	5.1303***	18.742***	-0.0003505***	7.99	0.537
	(1.1214)	(1.1148)	(0.000020398)		
(12)oil seed, oleagi fruits; miscell grain, seed, fruit etc	5.5245***	16.37***	-0.00048471***	7.83	0.602
	(1.0248)	(0.87536)	(0.000023991)		
(84)Nuclear reactors, boilers, mchy & mech appliance; parts	3.3846	63.684***	-0.000081686**	7.74	0.269
	(2.1999)	(7.1282)	(0.000041665)		
(25)Salt; sulphur; earth & ston; plastering mat; lime & cem	5.5551***	25.345***	-0.00025223***	7.71	0.424
	(1.3798)	(1.8813)	(0.000022611)		
(66)Umbrellas, walking-sticks, seat-sticks, whips, etc	-0.81307	5.9734***	-0.00043025	7.70	0.232
	(0.7125)	(0.40456)	(0.000019967)		
(3)Fish & crustacean, mollusc & other aquatic invertebrate	3.6447***	17.348***	-0.00014119***	7.62	0.347
	(1.1203)	(1.1922)	(0.000018191)		
(44)Wood and articles of wood; wood charcoal.	5.0932***	19.63***	-0.00028206***	7.56	0.481
	(1.1912)	(1.3012)	(0.000019645)		
(10)Cereals.	-3.872***	2.6261***	-0.00028794***	7.35	0.412
	(0.72428)	(0.34585)	(0.000015918)		
(51)Wool, fine/coarse animal hair, horsehair yarn & fabric	3.4013***	10.844***	-0.0004421***	7.23	0.490
	(0.83693)	(0.55547)	(0.000021057)		
(72)Iron and steel.	7.3268***	32.146***	-0.00015189***	6.87	0.345
	(1.9992)	(2.7081)	(0.000026988)		
(89)Ships, boats and floating structures.	3.9627***	15.213***	-0.00011243***	6.50	0.281
	(1.1007)	(1.1167)	(0.000017758)		
(27)Mineral fuels, oils & product of their distillation; etc	7.3128***	23.69***	-0.0002663***	6.47	0.442
	(1.5119)	(1.7376)	(0.000022011)		
(43)Furskins and artificial fur; manufactures thereof.	0.8091	6.3416***	-0.00042196	6.29	0.283
	(0.72146)	(0.40825)	(0.000019531)		
(53)other vegetable textile fibres; paper yarn & woven fab	3.2606***	9.3454***	-0.00043642***	6.22	0.437
	(0.80682)	(0.50295)	(0.000020539)		
(1)Live animals.	0.59372	6.0334***	-0.00044556	6.19	0.257
	(0.71572)	(0.40734)	(0.00002048)		
(26)ores, slag and ash.	1.367*	5.7226***	-0.00019256***	4.81	0.208
	(0.74417)	(0.38966)	(0.000014126)		
(5)Products of animal origin, nes or included.	4.1217***	8.8039***	-0.00039176***	4.74	0.433
	(0.82363)	(0.4825)	(0.000018797)		
(41)Raw hides and skins (other than furskins) and leather.	6.8762***	11.858***	-0.00034621***	3.73	0.471
	(1.0708)	(0.70188)	(0.000018903)		
(6)Live tree & other plant; bulb, root; cut flowers etc	4.2697***	6.0453***	-0.00037593***	1.95	0.330
	(0.77858)	(0.39919)	(0.000018057)		
(47)Pulp of wood/of other fibrous cellulosic mat; waste etc	7.885***	6.7691***	-0.00028072***	-0.93	0.339
	(1.0648)	(0.44477)	(0.000015933)		

Note: For expository purpose, coefficients for GDPIM and GDPR are presented after original estimated coefficients are multiplied by 1,000,000,000,000,000. Figures in parenthesis are heteroskedastic consistent standard errors. *, **, *** denote statistical significance at ten, five, and one percent level, respectively. HME test represents statistics given in equation (31) and critical value for ten percent significance level is 1.282.

Table 4. Export Ratio Regression

Industry	f(dist)*L_im	f(dist)*L_reg	NOB	Adj. R^2	ER Stat	ER test
(1)Live animals.	-0.00019907 (0.00074648)	-0.017564*** (0.004276)	1044	0.526	0.017	3.821
(2)Meat and edible meat offal.	-0.0019576*** (0.00071162)	-0.01361*** (0.0036141)	1044	0.545	0.012	3.013
(3)Fish & crustacean, mollusc & other aquatic invertebrate	-0.00026839 (0.00042042)	-0.0027221 (0.0018262)	1368	0.626	0.002	1.241
(4)Dairy prod; birds' eggs; natural honey; edible prod nes	-0.0016424** (0.00068054)	-0.021584*** (0.0031392)	1269	0.538	0.020	5.898
(5)Products of animal origin, nes or included.	0.00051734 (0.00066906)	-0.0053671* (0.00313)	1323	0.459	0.006	1.747
(6)Live tree & other plant; bulb, root; cut flowers etc	-0.00073101 (0.00076819)	-0.0086128** (0.0035533)	1179	0.309	0.008	2.059
(7)Edible vegetables and certain roots and tubers.	-0.00043406 (0.00059926)	-0.0074432*** (0.0025972)	1314	0.606	0.007	2.504
(8)Edible fruit and nuts; peel of citrus fruit or melons.	-0.00053383 (0.0005434)	0.0060516** (0.0023706)	1287	0.773	-0.007	-2.597
(9)Coffee, tea, mat・and spices.	-0.00010012 (0.00050532)	-0.0080848*** (0.0021951)	1368	0.688	0.008	3.361
(10)Cereals.	-0.0013942* (0.00081063)	-0.018151** (0.008237)	765	0.572	0.017	1.984
(11)Prod mill indust; malt; starches; inulin; wheat gluten	-0.00011925 (0.00047037)	0.00006821 (0.0020432)	1368	0.655	0.000	-0.085
(12)oil seed, oleagi fruits; miscell grain, seed, fruit etc	-0.0007083** (0.00027468)	-0.0012806 (0.0011932)	1368	0.889	0.001	0.443
(13)Lac; gums, resins & other vegetable saps & extracts.	-0.0014011*** (0.00050343)	0.01265*** (0.0021868)	1368	0.656	-0.014	-5.937
(14)Vegetable plaiting materials; vegetable products nes	-0.0013363* (0.00077672)	-0.011408*** (0.0036596)	1233	0.407	0.010	2.560
(15)Animal/veg fats & oils & their cleavage products; etc	-0.00053211 (0.00033233)	0.0028804** (0.0014436)	1368	0.835	-0.003	-2.184
(16)Prep of meat, fish or crustaceans, molluscs etc	-0.003093*** (0.00044758)	0.0060216*** (0.0019442)	1368	0.725	-0.009	-4.332
(17)Sugars and sugar confectionery.	-0.0018921*** (0.00047373)	0.0029071 (0.0020578)	1368	0.612	-0.005	-2.155
(18)Cocoa and cocoa preparations.	-0.00049693 (0.0006839)	0.0029127 (0.0030008)	1332	0.571	-0.003	-1.054
(19)Prep of cereal, flour, starch/milk; pastrycooks' prod	-0.0016192*** (0.00036352)	-0.0087262*** (0.0015791)	1368	0.807	0.007	4.158
(20)Prep of vegetable, fruit, nuts or other parts of plants	-0.0018144*** (0.00052533)	0.0068742*** (0.002282)	1368	0.617	-0.009	-3.518
(21)Miscellaneous edible preparations.	-0.0011129*** (0.00025668)	-0.0070829*** (0.001115)	1368	0.884	0.006	4.947
(22)Beverages, spirits and vinegar.	-0.00073988** (0.00035363)	-0.0018544 (0.0015361)	1368	0.829	0.001	0.670
(23)Residues & waste from the food indust; prepr ani fodder	-0.00086675** (0.00039011)	-0.0069112*** (0.0016946)	1368	0.678	0.006	3.296
(24)Tobacco and manufactured tobacco substitutes.	0.0022015*** (0.00082926)	-0.029514*** (0.0033604)	1152	0.581	0.032	8.631

Industry	f(dist)*L_im	f(dist)*L_reg	NOB	Adj. R^2	ER Stat	ER test
(25)Salt; sulphur; earth & ston; plastering mat; lime & cem	-0.00053577 (0.00037448)	0.00079151 (0.0016267)	1368	0.621	-0.001	-0.754
(26)ores, slag and ash.	-0.00024748 (0.00065431)	0.0081626*** (0.0029013)	1332	0.446	-0.008	-2.683
(27)Mineral fuels, oils & product of their distillation; etc	0.000019927 (0.00039957)	0.0055058*** (0.0017357)	1368	0.595	-0.005	-2.920
(28)Inorgn chem; compds of prec met, radioact elements etc	-0.0002247 (0.00025442)	-0.0045849*** (0.0011052)	1368	0.824	0.004	3.645
(29)organic chemicals.	-0.00044785** (0.00022022)	-0.0032023*** (0.0009566)	1368	0.780	0.003	2.661
(30)Pharmaceutical products.	-0.00053374* (0.00029796)	-0.00040396 (0.0012943)	1368	0.863	0.000	-0.093
(31)Fertilizers.	-0.00010134 (0.00050561)	-0.00073933 (0.0021963)	1368	0.490	0.001	0.268
(32)Tanning/dyeing extract; tannins & derivs; pigm etc	-0.00026513 (0.00025872)	0.0042531*** (0.0011238)	1368	0.875	-0.005	-3.715
(33)Essential oils & resinoids; perf, cosmetic/toilet prep	-0.00067084*** (0.00022733)	-0.0078226*** (0.00098751)	1368	0.923	0.007	6.692
(34)Soap, organic surface-active agents, washing prep, etc	-0.00074552*** (0.0002625)	0.0031151*** (0.0011403)	1368	0.866	-0.004	-3.128
(35)Albuminoidal subs; modified starches; glues;	-0.00079492*** (0.00025788)	0.0037694*** (0.0011202)	1368	0.880	-0.005	-3.765
(36)Explosives; pyrotechnic prod; matches; pyrop alloy; etc	-0.00088861 (0.00072097)	-0.0091914*** (0.0031619)	1278	0.568	0.008	2.429
(37)Photographic or cinematographic goods.	-0.0013179*** (0.00025332)	-0.014696*** (0.0011004)	1368	0.943	0.013	11.233
(38)Miscellaneous chemical products.	-0.000087163 (0.00027844)	0.0011588 (0.0012095)	1368	0.838	-0.001	-0.952
(39)Plastics and articles thereof.	-0.00080439*** (0.0001808)	-0.0012949* (0.00078537)	1368	0.923	0.000	0.577
(40)Rubber and articles thereof.	-0.00029957 (0.00018553)	-0.0026755*** (0.00080593)	1368	0.893	0.002	2.724
(41)Raw hides and skins (other than furskins) and leather.	-0.00033848 (0.00043146)	0.0085659*** (0.0019265)	1359	0.730	-0.009	-4.283
(42)Articles of leather; saddlery/harness; travel goods	-0.0013463*** (0.00043815)	-0.0045725** (0.0019033)	1368	0.747	0.003	1.566
(43)Furskins and artificial fur; manufactures thereof.	-0.0011524* (0.00062235)	-0.0010322 (0.0031226)	1143	0.639	0.000	-0.036
(44)Wood and articles of wood; wood charcoal.	-0.00059708 (0.00039753)	-0.0058316*** (0.0017269)	1368	0.684	0.005	2.801
(45)Cork and articles of cork.	-0.0010233 (0.00069235)	0.0057157* (0.0030206)	1314	0.546	-0.007	-2.067
(46)Manufactures of straw, esparto/other plaiting mat; etc	-0.0002369 (0.00070705)	-0.0042934 (0.0034159)	1242	0.479	0.004	1.104
(47)Pulp of wood/of other fibrous cellulosic mat; waste etc	0.00087714 (0.00068381)	0.0063894** (0.0029886)	1332	0.447	-0.006	-1.706
(48)Paper & paperboard; art of paper pulp, paper/paperboard	-0.00072355*** (0.00019193)	-0.0037712*** (0.00083371)	1368	0.869	0.003	3.378

Note: For expository purpose, coefficients for f(dist)*L_im and ER statistics are presented after original estimated coefficients are multiplied by 1,000,000,000,000,000. Figures in parenthesis are heteroskedastic consistent standard errors. *, **, *** denote statistical significance at ten, five, and one percent level, respectively. ER stat is the difference between two coeeficients and ER test represents statistics given in equation (35) where critical value for ten percent significance level is 1.282.

Table 4 (continued). Export Ratio Regression

Industry	f(dist)*L_im	f(dist)*L_reg	NOB	Adj. R^2	ER Stat	ER test	Industry	f(dist)*L_im	f(dist)*L_reg	NOB	Adj. R^2	ER Stat	ER test
(49)Printed books, newspapers, pictures & other product etc	-0.0017477*** (0.00031614)	-0.01226*** (0.0013733)	1368	0.845	0.011	7.073	(73)Articles of iron or steel.	0.000091482 (0.00020005)	-0.00073713 (0.00086898)	1368	0.881	0.001	0.881
(50)Silk.	-0.00057918 (0.00052805)	-0.0051926** (0.0023039)	1332	0.716	0.005	1.851	(74)Copper and articles thereof.	-0.00098693*** (0.00025441)	-0.00026648 (0.0011051)	1368	0.832	-0.001	-0.602
(51)Wool, fine/coarse animal hair, horsehair yarn & fabric	-0.00042499 (0.00037522)	0.0052675*** (0.0016754)	1359	0.861	-0.006	-3.149	(75)Nickel and articles thereof.	-0.0012352*** (0.0004642)	-0.0019334 (0.0020164)	1368	0.686	0.001	0.320
(52)Cotton.	-0.00037479 (0.00026953)	0.0019147 (0.0011708)	1368	0.940	-0.002	-1.807	(76)Aluminium and articles thereof.	-0.00079563*** (0.00027021)	0.00057075 (0.0011738)	1368	0.849	-0.001	-1.076
(53)other vegetable textile fibres; paper yarn & woven fab	-0.00018732 (0.0003842)	0.0047946*** (0.0016689)	1368	0.869	-0.005	-2.758	(78)Lead and articles thereof.	-0.0012947*** (0.00049353)	0.000066174 (0.0021438)	1368	0.652	-0.001	-0.587
(54)Man-made filaments.	-0.00021328 (0.00028868)	0.0032002** (0.001254)	1368	0.909	-0.003	-2.515	(79)Zinc and articles thereof.	-0.00042379 (0.00053494)	-0.010244*** (0.0023237)	1368	0.557	0.010	3.905
(55)Man-made staple fibres.	-0.00044069 (0.00030237)	0.00153 (0.0013135)	1368	0.896	-0.002	-1.386	(80)Tin and articles thereof.	0.00045949 (0.00049672)	0.0014089 (0.0021947)	1359	0.719	-0.001	-0.400
(56)Wadding, felt & nonwoven; yarns; twine, cordage, etc	-0.00016805 (0.00026148)	0.0012314 (0.0011358)	1368	0.892	-0.001	-1.138	(81)other base metals; cermets; articles thereof.	-0.00049633 (0.0004222)	-0.0061917*** (0.001834)	1368	0.750	0.006	2.869
(57)Carpets and other textile floor coverings.	-0.00049194 (0.0005452)	-0.0028792 (0.0023683)	1368	0.651	0.002	0.931	(82)Tool, implement, cutlery, spoon & fork, of base met etc	-0.0006445*** (0.00021506)	-0.0032904*** (0.00093418)	1368	0.894	0.003	2.617
(58)Special woven fab; tufted tex fab; lace; tapestries etc	-0.00037258 (0.00031474)	0.00086551 (0.0013672)	1368	0.872	-0.001	-0.837	(83)Miscellaneous articles of base metal.	-0.00040017 (0.00026952)	0.0035644*** (0.0011708)	1368	0.858	-0.004	-3.129
(59)Impregnated, coated, cover/laminated textile fabric etc	-0.0004284 (0.00026491)	0.0055781*** (0.0011507)	1368	0.896	-0.006	-4.823	(84)Nuclear reactors, boilers, mchy & mech appliance; parts	-0.00034104** (0.00016064)	-0.0043*** (0.00069781)	1368	0.929	0.004	5.242
(60)Knitted or crocheted fabrics.	0.000019281 (0.00028192)	-0.0004235 (0.0012246)	1368	0.925	0.000	0.334	(85)Electrical mchy equip parts thereof; sound recorder etc	-0.00070894*** (0.00018086)	-0.010308*** (0.00078565)	1368	0.931	0.010	11.289
(61)Art of apparel & clothing access, knitted or crocheted.	-0.00010828 (0.00032714)	-0.0033713** (0.0014211)	1368	0.847	0.003	2.122	(86)Railw/tramw locom, rolling-stock & parts thereof; etc	-0.00060494 (0.00063972)	-0.016896*** (0.0027789)	1368	0.510	0.016	5.417
(62)Art of apparel & clothing access, not knitted/crocheted	0.00052856 (0.00037457)	-0.0091225*** (0.0016271)	1368	0.796	0.010	5.480	(87)Vehicles o/t railw/tramw roll-stock, pts & accessories	-0.00033082 (0.0002281)	-0.0047335*** (0.00099086)	1368	0.868	0.004	4.105
(63)other made up textile articles; sets; worn clothing etc	-0.0005174 (0.00033346)	-0.0043434*** (0.0014485)	1368	0.795	0.004	2.441	(88)Aircraft, spacecraft, and parts thereof.	-0.00093608 (0.00062197)	-0.0091132*** (0.0027018)	1368	0.645	0.008	2.796
(64)Footwear, gaiters and the like; parts of such articles.	-0.00027274 (0.00035435)	-0.0040012*** (0.0015393)	1368	0.808	0.004	2.238	(89)Ships, boats and floating structures.	0.0015512*** (0.00058074)	0.00030218 (0.0025227)	1368	0.306	0.001	0.457
(65)Headgear and parts thereof.	-0.0017565*** (0.00050264)	0.0087151*** (0.0022786)	1350	0.707	-0.010	-4.266	(90)optical, photo, cine, meas, checking, precision, etc	-0.00098084*** (0.00021778)	-0.0079733*** (0.00094602)	1368	0.927	0.007	6.829
(66)Umbrellas, walking-sticks, seat-sticks, whips, etc	-0.0015364** (0.00062564)	0.0094108*** (0.0028819)	990	0.618	-0.011	-3.520	(91)Clocks and watches and parts thereof.	-0.00086941** (0.00042187)	-0.014439*** (0.0018326)	1368	0.788	0.014	6.842
(67)Prepr feathers & down; arti flower; articles human hair	-0.00053894 (0.00065768)	-0.016827*** (0.0029724)	1287	0.577	0.016	5.078	(92)Musical instruments; parts and access of such articles	-0.00053235* (0.00027641)	-0.0031585*** (0.0012007)	1368	0.901	0.003	2.021
(68)Art of stone, plaster, cement, asbestos, mica/sim mat	-0.0012088*** (0.00022605)	-0.0020128** (0.00098195)	1368	0.877	0.001	0.756	(93)Arms and ammunition; parts and accessories thereof.	-0.0013133 (0.0013712)	-0.0053205 (0.0041167)	891	0.406	0.004	0.860
(69)Ceramic products.	-0.00070478* (0.00040973)	0.0061992*** (0.0017798)	1368	0.684	-0.007	-3.584	(94)Furniture; bedding, mattress, matt support, cushion	-0.0015391*** (0.00031328)	-0.0083349*** (0.0013608)	1368	0.810	0.007	4.614
(70)Glass and glassware.	-0.000065167 (0.00032909)	0.00015113 (0.0014295)	1368	0.780	0.000	-0.140	(95)Toys, games & sports requisites; parts & access	-0.0008681** (0.00034394)	-0.0048957*** (0.001494)	1368	0.796	0.004	2.491
(71)Natural/cultured pearls, prec stones & metals, coin etc	-0.0010591*** (0.00032964)	-0.0098825*** (0.0014319)	1368	0.884	0.009	5.693	(96)Miscellaneous manufactured articles.	-0.00017238 (0.00027631)	-0.0019227 (0.0012003)	1368	0.866	0.002	1.347
(72)Iron and steel.	0.00028783** (0.00013725)	-0.003739*** (0.00059622)	1368	0.918	0.004	6.240	(97)Works of art, collectors' pieces and antiques.	0.000012087 (0.00068532)	-0.010347*** (0.0030557)	1206	0.536	0.010	3.140

Note: For expository purpose, coefficients for f(dist)*L_im and ER statistics are presented after original estimated coefficients are multiplied by 1,000,000,000,000,000. Figures in parenthesis are heteroskedastic consistent standard errors. *, **, *** denote statistical significance at ten, five, and one percent level, respectively. ER stat is the difference between two coeeficients and ER test represents statistics given in equation (35) where critical value for ten percent significance level is 1.282.