Measuring Barriers to International Division of Labor in East Asia

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Abstract

International fragmentation has dramatically developed in East Asia since the 1990s. The purpose of this paper is to measure border barriers in transactions of intermediate goods in East Asian countries. We find that the barriers in each country have steadily declined since 1985. While the barriers in China and Taiwan have remarkably declined since the 1980s, those in Indonesia experienced a slight increase in the same decade. Furthermore, these results are qualitatively unchanged even if we control the effect of agglomeration on intra-regional inputs.

Keywords: border effect; fragmentation; agglomeration; East Asia

JEL Classification: D23; F15; R12; R15

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1 Introduction

In East Asia, international fragmentation has dramatically developed since the 1990s. Fragmentation has changed trade, foreign direct investment, and the strategy for economic growth in East Asia. Now, it is widely recognized that the reference to fragmentation is indispensable in studying recent East Asian economy.

International fragmentation has been studied since the last decade, e.g., Jones and Kierzkowski (1990). More recently, fragmentation is often argued in the context of vertical foreign direct investment (Navaretti and Venables, 2004). Those studies show that once fragmentation becomes possible, countries come to engage in production-process-wise vertical division of labor making use of differences in location advantages. In other words, in the international division of labor, each country produces and exports intermediate goods in which it has comparative advantage.

Fragmentation theory also tells us that one of the most important conditions for the development of international fragmentation is the reduction of the barriers and costs to international division of labor, which are often called "service link costs". Another important condition is the existence of a large difference in location advantages. Due to the dramatic development of international fragmentation, it is expected that those two conditions are well satisfied in East Asia.

International division of labor requires various costs to link remotely located production blocks. Kimura and Takahashi (2005) divide the costs mainly into four categories: trade costs, investment costs, communications costs and coordination costs. International fragmentation is adversely affected by policy barriers and problems relating to foreign direct investments (FDI) since a firm locates production blocks abroad and operates them through FDI. Communication and coordination costs are necessarily accompanied with the simultaneous operation of production blocks in multiple countries. If a reduction in production costs made possible by international division of labor overweighs service link costs incurred thereby, the firm breaks apart some of its production blocks to other remote locations, so as to attain a total cost reduction.

The purpose of this paper is to measure border barriers imposed *only* on intermediate goods transactions in East Asian countries. Kimura et al. (2006) show that some of service link costs have declined both quantitatively and qualitatively in East Asia. For instance, trade-weighted averages of MFN tariff rates on machinery sector declined steadily since the late 1980s. JETRO (2002) shows that ocean shipping costs in East Asian countries have decreased, and Hummels (1999) states that air freight costs have dramatically fallen all over the world. Although such direct measures are obviously the best means to examine the levels of barriers, there remain various unobservable barriers, such as contract enforcement costs in the second category and legal and regulatory costs in the first/second category. As a result, we cannot know how much the barriers in a mass have decreased and have discouraged international fragmentation. This paper investigates such barriers and presents their *ad valorem* tariff equivalent.

To measure the barriers in each East Asian country, we estimate an equation in which the dependent variable is a ratio of inter-regional to intra-regional input values in order to avoid some cumbersome issues. This "log odds ratio method" is employed in Head and Mayer (2000) and enables us to sidestep a problem that data of price indices are unavailable. Since last decade, a large amount of research on border-effects has been stimulated, using the gravity equation approach, e.g., McCallum (1995) and Anderson and van Wincoop (2004). The literature overcomes the problem by replacing variables on price index with importer dummies. In this paper, however, we cannot adopt the strategy since the barriers in each country are measured by examining coefficients for importer dummy variables. On the other hand, the log odds ratio method cancels out those unavailable variables and thus does not need data on price index in estimation.

In addition, our estimation equation is also useful in that the formulation of the equation hardly depends on underlying theoretical models, particularly on the sources of agglomeration benefits. The formulation is little changed even if, instead of Armington assumption, we suppose a monopolistic competition model with/without vertical/horizontal linkages[1] in the production of intermediate varieties. In estimating border barriers in transactions only on intermediate goods, it may be necessary to control the effect of agglomeration on intra-regional inputs since the development of a cluster in a country augments intra-regional inputs and overestimates the barriers in the country. Therefore, the flexibility in the formulation enables us to avoid specification error problems especially in specifying the equation to control the agglomeration effect.

Our findings are summarized as follows. The barriers in East Asia have steadily declined. In particular, the barriers in China and Taiwan have remarkably declined since the 1980s, while those in Indonesia experienced a slight increase in the same decade. Furthermore, these results are qualitatively unchanged even if we control the effect of agglomeration on intra-regional inputs. Therefore, we can conclude that barriers to international division of labor in East Asian countries have experienced a certain decrease particularly since the 1990s.

The rest of this paper is organized as follows. In section 2, we specify our estimation equations with referring to gravity equations. Section 3 argues on data used for the estimation, and the estimation results are presented in section 4. Section 5 concludes.

2 Econometric specification

This paper infers the barriers for international division of labor in East Asia. In approaching to measuring invisible barriers, this study takes steps similar to studies on border-effects. Therefore, we first survey studies on border-effects[2] and then specify our estimation equation for measuring the barriers to international division of labor.

2.1 Measuring border effects using gravity equation

A large amount of research has measured border barriers in inter-national trade against intra-national trade by using a gravity equation approach. In general, those studies estimate

$$\ln X_{ij} = \theta_0 + \theta_1 \ln Y_i + \theta_2 \ln Y_j + \theta_3 \ln \text{Distance}_{i,j} + \theta_4 \text{Border}_{i,j} + \varepsilon_{i,j}, \quad (1)$$

where $X_{i,j}$, Y_i, and $\text{Distance}_{i,j}$ are export value from country i to j, GDP in country i, and geographical distance between country i and j, respectively. $\text{Border}_{i,j}$ is an indicator variable that equals unity for intra-national trade and zero otherwise. Regressing this equation, we obtain the border effects on trade examining the estimated coefficient for Border variable, θ_4 (McCallum, 1995).

Recently, to obtain a more unbiased estimate of border-effects, the gravity equation has been re-derived from a model introducing trade costs (Anderson and van Wincoop, 2003). Then, separable preferences and technologies, and differentiated goods are assumed in order to obtain a gravity-like equation[3].

Supposing goods distinguished by country of origin and a CES type utility function, utility maximization by the representative consumer gives the following expression for the demand in country i for the good produced in country j, $c_{i,j}$.

$$c_{i,j} = \tau_{i,j}^{1-\rho} (p_j)^{-\rho} P_i^{\rho-1} E_i, \quad (2)$$

where τ, ρ, p, P, and E denote trade costs formulated by iceberg, the elasticity of substitution between goods, the producer price, the price index, and the total expenditure, respectively. Some manipulation using the market clearing condition and taking the logs yields[4]

$$\ln X_{i,j} = \beta_0 + \beta_1 \ln E_i + \beta_2 \ln E_j + \beta_3 \ln \tau_{i,j} + \beta_4 \ln P_i + \beta_5 \ln P_j + \varepsilon_{i,j},$$

where $X_{i,j}$ represents export values from country j to i (i's payments to j), i.e., $X_{i,j} \equiv p_j c_{i,j}$.

Assuming

$$\ln \tau_{i,j} \equiv \text{Border}_{i,j} + \gamma \ln \text{Distance}_{i,j},$$

the final equation is given by

$$\begin{aligned} \ln X_{i,j} = \beta_0 + \beta_1 \ln E_i + \beta_2 \ln E_j + \beta_6 \ln \text{Distance}_{i,j} + \beta_7 \text{Border}_{i,j} \\ + \beta_4 \ln P_i + \beta_5 \ln P_j + \varepsilon_{i,j}. \end{aligned} \quad (3)$$

Due to the assumption of homothetic preference, expenditure is proportional to consumer's total income and thus to Y in equation (1). Hence, a difference between conventional and this theory-based gravity equation is the existence of importer's and exporter's "multilateral resistance" terms. After moving Es to the LHS of this equation, Anderson and van Wincoop (2003) estimate using the method of non-linear least squares after solving for the multilateral resistance as a function of observable trade costs, and Feenstra (2002) estimates replacing multilateral resistance variables with importer dummies. As a result, the absolute value of the estimated coefficient for Border dummy turns out to be lower than that in the conventional gravity equation. In other words, the inferred border barriers become closer to realistic magnitude.

2.2 Specification

This paper measures border-barriers only for intermediate goods by basically employing the same setting given above. The trade in intermediate goods among East Asian countries is motivated by the difference in comparative/location advantages (Kimura et al., 2006) rather than by increasing returns to scale technology. Therefore, we assume that intermediate goods are distinguished by country of origin, i.e., Armington assumption. Technology in finished/downstream intermediate goods is separable among productive factors, and the sub-production function on intermediate goods is a CES type function. Then equation (2) is rewritten as follow:

$$z_{r,j} = t_{r,j}^{1-\sigma}(p_j)^{-\sigma}\Pi_r^{\sigma-1}E_r^I, \tag{4}$$

where $z_{r,j}$ is import demand in country r for intermediate goods produced in country j. σ, p_j, and Π_r denote the elasticity of substitution between intermediate goods, the producer price of the goods produced in country j, and the price index in country r, respectively. E_r^I is total expenditure on intermediate inputs in country r. Trade in intermediate goods between country r and s is modeled as facing Samuelsonian iceberg costs, $t_{r,s}$.

To sidestep some cumbersome issues, we do not employ a gravity equation. As usual, appropriate data on price index of intermediate goods, Π_r, are unavailable. Furthermore, we cannot replace variables for the price index with importer dummy variables since barriers in each country are measured by examining coefficients for importer dummy variables. To avoid this difficulty, we employ the method of "log odds ratios" used in Head and Mayer (2000). The purpose of their paper is to estimate border effects in each industry, while our purpose is to estimate those in each East Asian country. They estimate an equation in which the dependent variable is a log ratio of inter-national to intra-national input values, and this formulation enables us to cancels out variables relating to the price index and any identical elements between countries.

From equation (4), we obtain a ratio of input values in country r for the intermediate goods produced in country j to the values for the goods produced domestically, $Z_{r,j}$ as

$$Z_{r,j} \equiv \frac{p_j z_{r,j}}{p_r z_{r,r}} = \left(\frac{t_{r,j}}{t_{r,r}}\right)^{1-\sigma} \left(\frac{p_j}{p_r}\right)^{1-\sigma}. \tag{5}$$

This formulation relates the decisions of finished/downstream intermediate goods producers in country r on how to allocate expenditure between intermediate goods produced in country j and the goods produced domestically.

This method is quite useful in that the formulation of the equation hardly depends on underlying theoretical models. Supposing a monopolistic competition model as in Head and Mayer (2000), we need only to multiply a ratio of the number of firms in country r (n_r) to that in country j (n_j) with the RHS of equation (5). Moreover, even if we add the assumption of production structure of horizontal linkages (input-output relationship among intermediate goods) in the monopolistic competition model as in Krugman and Venables (1995) and Hillberry and Hummels (2002), the change against equation (5) is the same as that in the monopolistic competition above. That is certainly the case with vertical linkages (input-output relationship between intermediate and finished goods) as in Amiti (2005). These are because a major change appears inside of total expenditure on intermediate inputs E, and the total expenditure is canceled out by the ratio method. As a result, when we suppose a monopolistic competition model with/without horizontal/vertical linkages in the production of intermediate varieties, equation (5) is rewritten[5] as

$$Z_{r,j} \equiv \frac{p_j n_j z_{r,j}}{p_r n_r z_{r,r}} = \left(\frac{n_j}{n_r}\right) \left(\frac{t_{r,j}}{t_{r,r}}\right)^{1-\sigma} \left(\frac{p_j}{p_r}\right)^{1-\sigma}. \tag{6}$$

Here, as usual, we assume identical technology across firms and countries. $z_{r,j}$ and p_j represent the demand in country r and the price of intermediate varieties differentiated by firms locating in country j, respectively. In section 3.3, the equation derived from a monopolistic competition model is also estimated in order to take the effect of agglomeration on intra-country inputs into consideration.

In equation (5), the difference in the price of intermediate goods, p_j/p_r, embodies the difference in comparative advantages (COMPARA$_{r,j}$) between country r and j due to differences in productivity/factor endowments. One may say that this term represents one of the most important factors in fragmentation, "a difference in location advantages".

Equation (5) indicates that, the larger the difference in productivity/factor endowments, or the lower the trade costs between countries, the larger the relative foreign inputs. Therefore, it can be said that the equation captures two important conditions for the development of international fragmentation; a large difference in location advantages and the reduction of service link costs.

We assume that trade costs primarily consist of transport costs incurred by geographical distance and of policy/non-policy barriers against foreign inputs, e.g., tariff rates. Thus we specify relative trade costs as

$$\ln\left(\frac{t_{r,j}}{t_{r,r}}\right) = \ln \mathrm{Barriers}_r + \varphi \ln \mathrm{Distance}_{r,j}, \tag{7}$$

where $\ln \mathrm{Distance}_{r,j} \equiv \ln d_{r,j} - \ln d_{r,r}$. $d_{r,j}$ is geographical distance between country r and j and is measured by greater circle between their respective capital cities. $d_{r,r}$ is intra-regional distance and is calculated as a radius of surface area in country r. Specifically, $d_{r,r} \equiv \sqrt{surface\ area_r/\pi}$.

Since barriers$_r$ is invisible and the data are unavailable, we catch Barriers in each country by examining coefficients for the importer dummy variable. The final equation we estimate is given by

$$\ln(Z_{r,j}) = \varsigma_0 + \left(\sum_{i=1}^{R-1} \varsigma_{1i} D_i\right) + \varsigma_2 \ln \mathrm{Distance}_{r,j} + \varsigma_3 \ln \mathrm{COMPARA}_{r,j} + \varepsilon_{r,j}, \tag{8}$$

where R and ε denote the number of countries and a normally distributed random error, respectively. D_i is a dummy variable taking the value 1 if $i = r$ and 0 otherwise. The coefficients for the importer dummy variables are often called “home bias” in Wei (1996). Consequently, $\ln \text{Barriers}_r$ is represented by $-\varsigma_{1,r}/(1-\sigma)$.

3 Data

This section argues on data used for estimation in next section. After stating data sources and the issues, a brief overview of the data is presented.

3.1 Data issue

We focus on input-output relationships among East Asian countries in machinery sector since machinery goods have played the most important role in the development of international fragmentation (see Kimura and Ando, 2003). Our sample consists of nine East Asian countries (China, Indonesia, Japan, Malaysia, Republic of Korea, the Philippines, Singapore, Taiwan, and Thailand) and the U.S. in the year 1985, 1990, and 1995.

Data on intermediate input values are obtained from Asian International Input-Output Table published by Institute of Developing Economies. As for data on comparative advantage, we simply use the difference in per capita GDP between trading partners in order to control differences in technology/factor prices. In theoretical prediction, as long as we assume that intermediate goods are skilled-labor-intensive goods, the larger the variable $\text{COMPARA}_{r,j}$, the more the intermediate goods are imported from country j.

Furthermore, as for data issues, three points are to be noted. First, in

1985, we exclude the case in which the Philippines is an importer since the value of domestic input in the Philippines has a negative value. Second, the input values between China and Korea in 1985, from Taiwan to China in 1985, and from Taiwan and Korea to China in 1990 are not reported. We treat them by adding dummy variables.

Third, it is necessary to exclude one country in importer dummy variables in order to avoid dummy trap. As such a country, we select Singapore since there are few policy barriers. The remaining barriers seem to be universal non-policy barriers, e.g., modular-technique categorized in coordination costs, which are captured by a constant term in regression. In Singapore, tariff rates in machinery sector have been close to zero; 0.018% in 1985, 0.017% in 1990, and 0.004% in 1995[6].

Assuming that Singapore-specific barriers and the elasticity of substitution are almost constant during the period, we investigate the changes in *country specific barriers* in each country by examining the changes in coefficients for importer dummy variables.[7]

3.2 Overview

In this sub section, a brief overview of data on inter-regional inputs is presented. In order to enable us to make a time-series comparison, we here use the data excluding the transactions listed in the second data issue.

Figure 1 depicts the sum of input values from nine East Asian countries (excluding domestic inputs) in each country. The sum in country r is

$\sum_{i \neq r} p_i z_{ri}$. This figure shows that inter-regional inputs have increased in all countries. There is, however, a clear contrast. The increases in developed countries, particularly in Singapore and Japan, are outstanding. Malaysia, China, and Thailand also augment foreign intermediate inputs. On the other hand, inter-regional input values in the Philippines and Indonesia have been low. Therefore, the figure may imply that barriers to international division of labor in the Philippines and Indonesia have not declined relative to those in the other countries.

Figure 2 shows a ratio of the sum to domestic input values in each country. Two findings are to be noted. First, the ratio in each country has not necessarily risen despite the fact that international fragmentation in East Asia has developed. This means that domestic inputs have also increased remarkably due to technological advances, the development of agglomeration in intermediate goods producers, and so on.

Second, the ratio in Japan, Korea, and China is relatively low. This may be due to centripetal/centrifugal forces in those countries. Agglomeration theory, e.g., Fujita, Krugman, and Venables (1999, Ch. 14), tells the non-monotonic effect of trade costs on the pattern of manufacturing distribution; concentrating in intermediate trade costs and dispersion in high/low trade costs. Intuitively, the trade costs in Japan and Korea are at an intermediate/low level, and those in China are at a high level, relative to those in the other countries including Singapore. Thus, compared with the other countries, intermediate goods producers may concentrate on Japan and Korea, while China may keep the producers in domestic market due to the high trade costs.

Consequently, such existence of intermediate goods producers in domestic market may increase the own inputs, resulting in the small ratio in those countries. This implies that we need to estimate the equation derived from agglomeration models, say, the equation derived from (6), in order to control the effect of scale economy on intra-regional inputs.

4 Empirical results

In this section, we measure barriers to international division of labor in East Asia by estimating the equation derived in section 2.2. First, the basic results obtained from the estimation of equation (8) are reported. Next, we show the results with controlling the effect of agglomeration in intra-regional inputs.

4.1 Basic results

Table 1 reports the results in the estimation of equation (8) by ordinary least squares (OLS). First, let us take a look at the result in DISTANCE and COMPARA. Coefficients for the variables have the expected signs and are statistically significant; international fragmentation is positively correlated with income gap between partners, and is adversely affected by geographical distance between them, with their signs and statistical significance being quite stable over time. These changes in coefficients are similar to those in Kimura et al. (2006) and are explained as follows.

Before the formation of international production/distribution networks in East Asia, Japan was the only predominant exporter of intermediate goods. Therefore, in the 1980s, income gap between trade partners explains much more cross-sectional variation of international division of labor than geographical distance. In the first half of the 1990s, other countries also came to export many intermediate goods. Above all, developing countries started to participate in the networks and engage in transactions with relatively near countries. For example, input-output transactions between Singapore and Malaysia increased remarkably. Transactions between developing countries with relatively small income disparity, such as between the Philippines and China, increased even if the distance between them is not small. Therefore, the coefficient for distance experiences a decrease (up to zero), and the magnitude of coefficient for income gap becomes smaller.

Coefficients for importer dummy variables are estimated negatively significant. Remember that natural logarithm of barriers in each country is represented by a coefficient for each importer dummy variable divided by $(1-\sigma)$. Although there are several ways to express the magnitude of the barriers as summarized in Head and Mayer (2000), we here present the tariff equivalent of the barriers. The *ad valorem* tariff equivalent is calculated by (exp(dummy coef./$(1-\sigma)$)-1) and is shown in Table 2. This requires the value of the elasticity of substitution. Head and Ries (2001) and Hanson (2005) obtained estimates of σ ranged between 7 and 11 and between 5 and 8, respectively. Anderson and van Wincoop (2004) state that "overall the literature leads us to conclude that σ is likely to be in the range of 5 to 10". We here choose 9 for σ though choice of the value has little influence on *changes* in the barriers as long as assuming that the elasticity is constant during the period.

Let us start our analysis on the barriers by providing an overview on the relative magnitudes in each country. In the year 1985, from the viewpoint of the level of barriers, countries are categorized into three groups. China belongs to the group with the highest barriers, and Malaysia to the group with the lowest barriers. The rest of the countries are in the group with intermediate barriers. In the year 1995, notable differences within each category emerge. Taiwan turns out to be a member of the low barriers group. On the other hand, Indonesia and the Philippines lag behind other ASEAN countries in terms of reducing the barriers.

Let us take a closer look at the changes in barriers in each country. The barriers in Malaysia and Indonesia rose slightly from 1985 to 1990 and have declined since 1990.[8] In Indonesia, the tariff equivalent of the barriers rose from 121% in 1985 to 174% in 1990 and declined then to 98% in 1995. Indeed, it is since the 1990s that large projects for removing trade barriers have been promoted in Indonesia though the rise in the 1980s seems to be unbelievable result. On the other hand, the barriers in Malaysia have already been relatively low and are even lower than those in developed countries. The tariff equivalent in 1995 is only 29%. In Malaysia, agglomeration of electric machinery has developed especially through the entry of Japanese multinational firms for a long time, and firms locating in the agglomeration import large quantities of electric machinery parts and components. Therefore, in Malaysia, the reduction particularly on investment costs may have led to the extremely low barriers.

The barriers in Thailand and the Philippines have experienced a remarkable decline since the 1980s. The tariff equivalent in Thailand and the Philippines declined from 128% in 1985 to 44% in 1995 and from 145% in 1990 to 69% in 1995, respectively. On the other hand, in China, we find statistically that the decline starts in full swing particularly in the 1990s. The tariff equivalent decreased from 393% in 1990 to 186% in 1995. This may imply that the "Open Door" policy, which was introduced by Deng Xiapping, contributes largely to the decline of barriers in China.

In developed countries in East Asia, all three countries have decreased their barriers since 1985. The barriers were lowered particularly in Taiwan, where inter-regional inputs (especially from Japan and the U.S.) have considerably increased. Furthermore, the decline in Taiwan has occurred more rapidly than in Korea and Japan. The tariff equivalent in Taiwan decreased from 104% in 1985 to 28% in 1995 while that in Japan and Korea from 101% to 54% and from 112% to 55% during the same period.

Notice that, although we assume that the barriers in Singapore are almost unchanged during the sample period, the decline in Singapore strengthens the results. Therefore, we can conclude that barriers to international division of labor in East Asian countries have experienced a notable decrease, particularly since the 1990s.

4.2 Controlling the agglomeration effect

Data overview in section 3.2 suggests that technological advances and agglomeration benefits in a country may augment domestic inputs. Consequently, this effect should raise the estimates of importer dummy variables.[9] In order to control the effect of agglomeration in intra-regional inputs, as argued in section 2.2, we estimate the equation derived from a monopolistic competition model (with/without vertical/horizontal linkages).

Denoting the total value of production on intermediate goods in country r and the quantity produced by each firm as m_r and q, respectively, we obtain $m_r = qp_r n_r$. Remember that we assume identical technology across firms and countries. Following Head and Mayer (2000), this relationship is used to eliminate the number of firms from an estimation equation since its appropriate data are unavailable. Substituting this into equation (6), the equation is re-written as

$$Z_{r,j} = \left(\frac{m_j}{m_r}\right)\left(\frac{t_{r,j}}{t_{r,r}}\right)^{1-\sigma}\left(\frac{p_j}{p_r}\right)^{-\sigma}.$$

Furthermore, in order to avoid simultaneity problem between $z_{k,i}$ and m_i, as in Head and Mayer (2000), we move m_i to the LHS as

$$\left(\frac{Z_{r,j}}{M_{r,j}}\right) = \left(\frac{t_{r,j}}{t_{r,r}}\right)^{1-\sigma}\left(\frac{p_j}{p_r}\right)^{-\sigma},$$

where $M_{r,j} \equiv m_j/m_r$. Using equation (7), we obtain

$$\ln\left(\frac{Z_{r,j}}{M_{r,j}}\right) = \theta_0 + \left(\sum_{i=1}^{R-1}\theta_{1i}D_i\right) + \theta_2 \ln \text{Distance}_{r,j} + \theta_3 \ln \text{COMPARA}_{r,j} + \varepsilon_{r,j}. \quad (9)$$

Data on the total value are also obtained from Asian International Input-Output Table. The tariff equivalent calculated from the results in OLS estimation of equation (9) is shown in Table 3. This table presents us various findings, but here we would like to emphasize two points.

First, we again find that the barriers in each country have experienced a certain decrease. Second, the tariff equivalent in some countries in Table 3 is lower than that in Table 2. In particular, as pointed out in section 3.2, the difference is larger in the countries with a small ratio in Figure 2, i.e., Japan, Korea, and China. This finding may imply that the agglomeration effect overestimates the barriers. In Japan, for example, the agglomeration effect raises the estimate of the tariff equivalent in 1995 by 22% (54%-32%).

5 Concluding remarks

This paper infers the barriers for international division of labor in East Asian countries. Empirical results show that the barriers in each country have steadily declined. In particular, developing countries have experienced a remarkable decline.

Our main data source is Asian international input-output table. The developing countries reported in the table have been relatively successful in attracting foreign direct investments. Since the second half of the 1980s, they have shifted their policies regarding foreign firms, from protection of indigenous firms to welcoming acceptance of foreign firms. Furthermore, they also have introduced trade mechanisms such as duty-drawback system and other FDI promotion measures in order to support those policies. These policy changes must have largely contributed to the remarkable decline in the barriers.

Notes

1. Here, vertical and horizontal linkages mean input-output relationship between intermediate and finished goods and among intermediate goods, respectively.

2. As for the more details, for example, see Poncet (2003).

3. Of course, these settings are not the only available ones that can be used to derive the gravity equation. For example, see Evenett and Keller (2002).

4. For a clear comparison with equation (1), it is assumed that the trade costs are symmetric. As for the more detailed derivation, see Anderson and van Wincoop (2003).

5. More properly, product prices are also changed among those models.

6. These rates are calculated by using data on import duties and foreign input values, which are obtained from Asian International Input-Output Table.

7. More properly, service link costs contain transport costs which are partly captured by the coefficient for distance variable. In this paper, however, barriers excluding the transport costs are called "barriers to international division of labor" because transportation fees per kilometer are almost identical at least within East Asia.

8. The sample size in 1985 is small relative to that in other years due to the exclusion of the Philippines, suggesting the counter-intuitive results may be due to such a difference in sample size. We re-estimated the equation in other years excluding the Philippines, confirming that the trend in all dummy variables is unchanged. Hence, the rise in barriers to international division of labor in Malaysia and Indonesia from 1985 to 1990 seems to be true.

9. Thus, a decrease on the estimates in Table 1 and 2 implies that international inputs due to international fragmentation have increased much more rapidly than intra-national inputs due to agglomeration.

References

[1] Amiti, M., 2005, Location of Vertically Linked Industries: Agglomeration versus Comparative Advantage. *European Economic Review*, 49, pp. 809-832.

[2] Anderson, J. E. and E. van Wincoop, 2003, Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review*, 93, pp. 170-192.

[3] Anderson, J. E. and van Wincoop, E., 2004, Trade Costs. *Journal of Economic Literature*, 42, pp. 691-751.

[4] Ando, M. and F. Kimura, 2005, The Formation of International Production and Distribution Networks in East Asia. In: International Trade in East Asia, (eds Ito T. and Rose A.), University of Chicago Press.

[5] Evenett, S. and W. Keller, 2002, On Theories Explaining the Success of the Gravity Equation. *Journal of Political Economy*, 110, pp. 281-316.

[6] Feenstra, R. C., 2002, Border Effects and the Gravity Equation: Consistent Methods for Estimation. *Scottish Journal of Political Economy*, 495, pp. 491-506.

[7] Hummels, D., 1999, Have International Transportation Costs Declined?. mimeo, Purdue University.

[8] Fujita, M., Krugman, P. R. and A. J. Venables, 1999, *The Spatial Economy: Cities, Regions, and International Trade*. The MIT Press.

[9] JETRO, 2002, *Comparative Analysis on Investment Environment in East Asia*. Japanese External Trade Organization, Overseas Research Series No. 357 (in Japanese).

[10] Jones, R. and H. Kierzkowski, 1990, The Role of Services in Production and International Trade: A theoretical framework. In: The Political Economy of International Trade: Essays in Honor of Robert E. Baldwin, (eds Jones R. and Krueger A.), Oxford: Basil Blackwell.

[11] Hanson, G., 2005, Market Potential, Increasing Returns, and Geographic Concentration. *Journal of International Economics*, 671, pp. 1-24.

[12] Head, K. and T. Mayer, 2000, Non-Europe: The Magnitude and Causes of Market Fragmentation in Europe. *Weltwirschaftliches Archiv*, 136, pp. 285-314.

[13] Head, K. and J. Ries, 2001, Increasing returns versus national product differentiation as an explanation for the pattern of US-Canada trade. *American Economic Review*, 91, pp. 858-76.

[14] Hillberry, R. and E. Hummels, 2002, Explaining Home Bias in Consumption: The Role of Intermediate Input Trade, National Bureau of Economic Research, Working Paper, #9020.

[15] Kimura, F. and Y. Takahashi, 2005, International Trade and FDI with Fragmentation: the Gravity Model Approach. mimeo, Keio University.

[16] Kimura, F., Y. Takahashi and K. Hayakawa, 2006, Fragmentation and Parts and Components Trade: Comparison between East Asia and Europe. KUMQRP Discussion Paper Series, No. 2005-030, Keio University.

[17] McCallum, J., 1995, National Borders Matter: Canada-U.S. Regional Trade Patterns. *American Economic Review*, 85, pp. 615-623.

[18] Navaretti, B. and A. J. Venables, 2004, *Multinational Firms in the World Economy*, Princeton University Press.

[19] Poncet, S., 2003, Measuring Chinese Domestic and International Integration. *China Economic Review*, 14, pp. 1-21.

[20] Wei, S-J., 1996, Intra-National Versus International Trade: How Stubborn Are Nations in Global Integration? National Bureau of Economic Research, Working Paper, #5531.

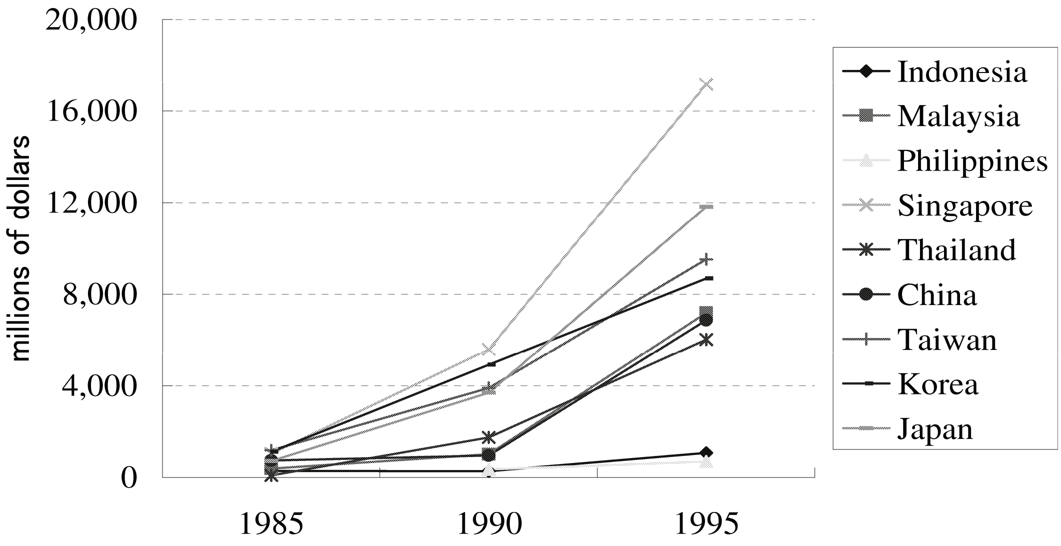

Figure 1: The sum of inter-regional input values

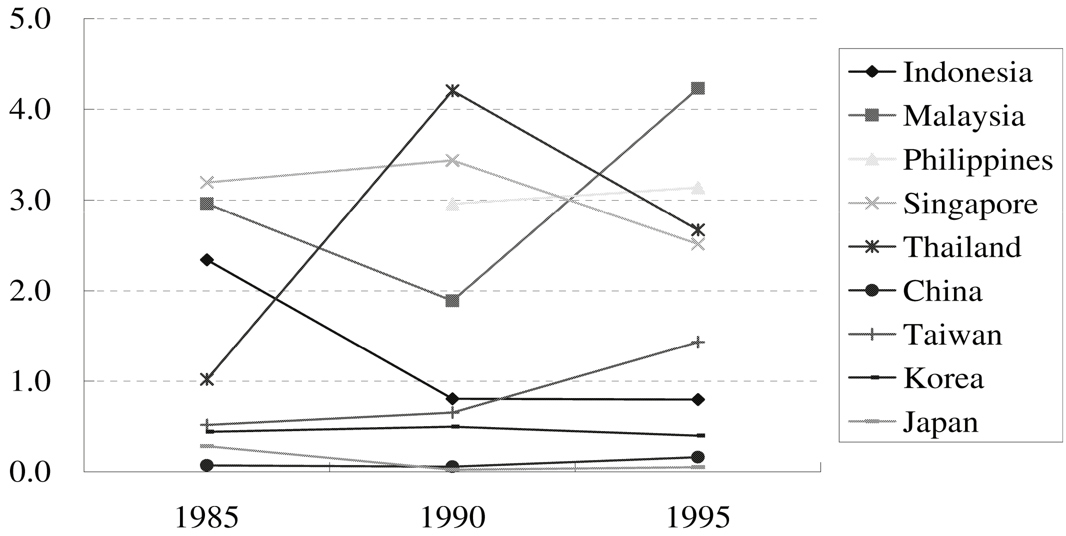

Figure 2: A ratio of the sum to intra-regional input values

Table 1: OLS estimation results

Variable	1985	1990	1995
Const	2.058*	2.293**	0.786
	(0.897)	(0.774)	(0.655)
DISTANCE	-0.302*	-0.341**	-0.163
	(0.147)	(0.127)	(0.110)
COMPARA	1.485**	1.429**	0.979**
	(0.111)	(0.112)	(0.087)
INDONESIA	-6.371**	-8.057**	-5.446**
	(0.960)	(0.937)	(0.798)
MALAYSIA	-3.271**	-4.562**	-2.043**
	(0.726)	(0.645)	(0.506)
PHILIPPINES		-7.17**	-4.175**
		(1.064)	(0.811)
THAILAND	-6.577**	-4.839**	-2.944**
	(0.888)	(0.730)	(0.601)
CHINA	-13.357**	-12.767**	-8.414**
	(1.065)	(0.957)	(0.802)
TAIWAN	-5.705**	-4.006**	-1.978**
	(0.550)	(0.505)	(0.452)
KOREA	-5.994**	-5.251**	-3.518**
	(0.579)	(0.568)	(0.485)
JAPAN	-5.596**	-4.500**	-3.428**
	(0.530)	(0.530)	(0.463)
US	-3.508**	-3.625**	-2.906**
	(0.576)	(0.614)	(0.472)
$\bar{R}^2$	0.8500	0.8258	0.7970
Obs.	81	90	90

Notes: A dependent variable is natural logarithm of a ratio of input values in country r for the intermediate goods produced in country j to the values for the goods produced domestically, $\ln Z_{r,j}$. DISTANCE and COMPARA are a ratio of inter-regional to intra-regional distance and a difference in per capita GDP between trading partners, respectively. Regional names represent importer dummy variables. ** shows 1 % and * shows 5 % significant. The inside of a parenthesis is a White consistent standard error. The coefficient for a dummy variable, which takes the value 1 in the input between China and Korea, from Taiwan to China in 1985, and from Taiwan and Korea to China in 1990 and 0 otherwise, is unreported.

Table 2: Tariff equivalent of the barriers in each country

	1985	1990	1995
Indonesia	122%	174%	98%
Malaysia	51%	77%	29%
Philippines		145%	69%
Thailand	128%	83%	44%
China	431%	393%	186%
Taiwan	104%	65%	28%
Korea	112%	93%	55%
Japan	101%	76%	54%

Notes: The *ad valorem* tariff equivalent is calculated by (exp(dummy coef./$(1-\sigma)$)-1). We choose 9 for σ.

Table 3: Tariff equivalent of the barriers with controlling the agglomeration effect

	1985	1990	1995
Indonesia	171%	214%	133%
Malaysia	76%	94%	39%
Philippines		200%	114%
Thailand	171%	105%	63%
China	296%	278%	131%
Taiwan	84%	54%	34%
Korea	88%	74%	51%
Japan	62%	43%	32%
$\bar{R}^2$	0.61	0.66	0.67
Obs.	81	90	90

Notes: See notes in Table 1 and 2. A dependent variable is $\ln Z_{r,j}$ divided by natural logarithm of a ratio of the number of firms in country j to that in country r. All independent variables are the same as those in Table 1. This table reports the tariff equivalent calculated from the regression results (OLS), adjusted R-square, and observation.