HITOTSUBASHI UNIVERSITY

Global COE Hi-Stat Discussion Paper Series 094

Research Unit for Statistical
and Empirical Analysis in Social Sciences (Hi-Stat)

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December 2009

Hi-Stat Discussion Paper

**Hi-Stat**
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# Gains from Fragmentation at the Firm Level:

# Evidence from Japanese Multinationals in East Asia

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**Abstract:** The unprecedented development of production networks in East Asia has been investigated, both theoretically and empirically, employing the conceptual framework of fragmentation theory and its extensions. However, the benefits of production fragmentation at the firm level, particularly benefits deriving from different location advantages, have never been directly measured empirically. This paper presents the very first attempt, to the authors' knowledge, to empirically capture the benefits of fragmentation. Specifically, using Japanese firm-level data, we find that the larger the gap in the capital-labor ratios between fragmenting firms' home and overseas activities, the more greatly their cost efficiency improves.

***Keywords*:** Firm heterogeneity; multinational enterprises; fragmentation; factor intensity; micro data

***JEL Classification*:** F21; F23

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[§] This research was conducted as part of a project of the Economic Research Institute for ASEAN and East Asia (ERIA) "Deepening East Asian Economic Integration Part II: Firm-Level Analyses". We thank the Ministry of Economy, Trade, and Industry of the Japanese government for providing the micro data used in this study. The authors are deeply indebted to the members of this project for their invaluable suggestions. The opinions expressed in this paper are the sole responsibility of the authors and do not reflect the views of the ERIA.

## 1. Introduction

The fragmentation theory initiated by Jones and Kierzkowski (1990) has had a great impact on the theoretical conceptualization of the production-process-wise division of labor developed between the North and South.[1] Notably, the unprecedented formation of production networks in East Asia has been investigated, both theoretically and empirically, with employing the conceptual framework of fragmentation theory and its extensions.[2] The fragmentation theory has indeed become a strong theoretical backbone for understanding the recent phenomenon of active North-South intra-industry trade. Applying gravity equations for bilateral trade data *at the industrial level*, some researchers have found more active trade in parts and components in country-pairs with larger differences in income in East Asia (see, for example, Athukorala and Yamashita, 2006; Kimura, Takahashi, and Hayakawa, 2007). However, the benefits of production fragmentation *at the firm level*, particularly benefits derived from utilizing different location advantages, have never been directly measured empirically. This short paper presents the very first attempt, to the authors' knowledge, to empirically capture the benefits of fragmentation, using rigorous econometric methods.

The basic concept of fragmentation is illustrated as Figure 1. Suppose that a firm originally has a large electronics factory that takes care of a long sequence of value chains from upstream to downstream. The electronics industry as a whole is physical-capital-intensive or human-capital-intensive, so that the factory is located in a developed country. If we take a look at the factory in details, we find that it consists of various production processes; some production processes are purely human-capital-intensive while others are labor-intensive. Thus, if the firm properly divides a factory into multiple production blocks and places them in various locations with different location advantages, the total production cost may be reduced. This is fragmentation. To make fragmentation economically viable, two conditions must be met. First, there must be a large reduction in production cost in production blocks, achieved by utilizing different location advantages. Secondly, the cost of the service links that connect remotely located production blocks must be reasonably low.

=== Figure 1 ===

[1] For the fragmentation theory and its applications, also see Arndt and Kierzkowski (2001), Cheng and Kierzkowski (2001), and articles in the special issue of *International Review of Economic and Finance* on "Outsourcing and Fragmentation: Blessing or Threat" (Vol. 14, Issue 3, 2005).

[2] Kimura and Ando (2005) extend the fragmentation framework to two dimensions, incorporating fragmentation along the geographical distance axis and along the integration (intra-firm vs. arm's length) axis. Kimura (2006) summarizes the nature and characteristics of East Asian production networks in the extended framework.

Note that the fragmentation theory does not directly include the mechanism by which the production blocks are separated. Suppose that production activities require two primary inputs, capital ($K$) and labor ($L$), and differences in location advantages between developed countries (DCs) and less developed countries (LDCs) are represented by differences in factor prices, $r$ and $w$. If a firm could freely separate production blocks, it would place a purely capital-using production block in a DC and a purely labor-using production block in a LDC, in order to fully exploit differences in factor prices. This, however, does not actually happen because a firm faces technological and managerial constraints in separating production blocks. Casual observations in a number of factory visits suggest that production blocks located in LDCs tend to be more labor-intensive than those in DCs, as we would expect. However, gaps in factor intensity between production blocks in LDCs and DCs differ widely across firms, and how far the differences in location advantages are exploited seems to determine the extent of gains from fragmentation.

This is actually a testable hypothesis with the data of Japanese firms and their foreign affiliates, though we have to tolerate various data limitations. What we will demonstrate is as follows: suppose that two firms initially exist in an industry and operate at home (a DC) with the same technology. They now draw lotteries as Melitz (2003), determine the magnitude of gaps in factor intensity between a production block which remains at home and the other located in a foreign country (a LDC), and conduct fragmentation. Applying a set of reasonable conditions proposed by Deardorff (2001), we graphically demonstrate that a firm with a larger gap in factor intensity in fragmentation presents better performance than the other. Our econometric exercise provides a robust support for this claim.

The rest of this paper is organized as follows: the next section provides the theoretical framework of our empirical analysis. Following the theoretical framework of Deardorff (2001), we show that international fragmentation with a larger gap in capital-labor ratios (KL ratios) between two production blocks leads to a larger total cost reduction. Section 3 specifies our empirical methodology and discusses data issues. Some data overview on the capital-labor ratios of Japanese MNEs and the empirical results are reported in section 4, and section 5 concludes.

## 2. Theoretical Framework

This section summarizes how the benefit from fragmentation is related to the gap

in capital-labor ratios between activities at home and abroad. To do that, we employ the fragmentation model, particularly the theoretical framework proposed by Deardorff (2001).

## 2.1. Fragmentation and the Gap in KL Ratios

Consider two countries with different factor prices under free trade. The one is the capital-abundant North, and the other is the labor-abundant South. We assume that sufficiently different factor endowments between countries make factor price equalization impossible. Unit isocost lines in both countries are shown in Figure 2 (lines ACD and BCE for South and North, respectively). In this paper, we focus on good X, which is assumed to be capital-intensive enough to be initially produced only in the North. In this framework, we consider the total cost of a firm that tries to fragment technology for producing X. The production of good X can be broken up into two fragments, which are assumed to follow Leontief fixed-coefficient technologies. It is also assumed that since the firm constitutes a sufficiently small part of the total economies, it takes factor prices in the two countries as given, and its changing to the fragmented technology does not cause a noticeable change in the factor prices in either country.

=== Figure 2 ===

We first consider the fragmentation that uses the same quantity of resources as the unfragmented technology. Deardorff (2001) calls such fragmentation "costless fragmentation". The amount of good X produced by the isoquant $X=1/p_x$ can also be produced using the capital-intensive fragment that requires the vector of factors shown as OZ and the labor-intensive fragment that requires the vector shown as ZY. Since the capital-labor ratio of fragment OZ is above the cutoff line OC, the capital-intensive fragment OZ will be produced in the North.

In this setting, Deardorff (2001) demonstrates that international fragmentation leads to total cost reduction. To see this, it is useful to draw some lines. The lines A'C'D' and B'C'E' are parallel to ACD and BCE respectively, and both lines are contracted toward the origin by the same proportion. The line B'C'E' passes through the tip of the arrow OZ and thus shows the factor combinations that cost as much as factor inputs in producing fragment OZ in the North. The amount of such cost becomes less than one dollar. Since point C' is placed on both A'C'D' and B'C'E', the factor combination at this point costs the same amount between the North and the South. Thus,

drawing vector C'Y' with the same length and direction as ZY, we can obtain the point Y', through which an isocost line shows the total cost for producing the capital-intensive fragment in the North and the labor-intensive fragment in the South. As a result, since the point Y' lies inside unit isocost line ACD, the use of fragmented technology reduces the cost if the fragments are produced in different countries. That is, in this setting, international fragmentation succeeds in reducing the total cost for the production of good X.[3]

We can derive a further meaningful result from the above framework. We consider two firms. While one firm conducts fragmentation with a large gap in capital-labor ratios between fragments (KL gap), the other firm does so with a small KL gap. Here we restrict our attention to the fragmentation in which the cost for producing the capital-intensive fragment does not depend on its KL ratio. This ensures that the KL gap *uniformly* expands as the KL ratio in the capital-intensive fragment rises. Thus, we can easily compare fragmentation between large and small KL gaps. Graphically, even if the KL ratio in capital-intensive fragment OZ changes, the tip of the arrow OZ is always placed on the line B'E'.[4]

The result is shown in Figure 3. Two fragments' vectors in the large KL gap fragmentation are shown as OZ and ZY, and those in the small KL gap fragmentation as OZ' and Z'Y. Notice that both points Z and Z' are placed on the line E'B' since the cost of producing the fragment does not depend on its KL ratio. The rest of the figure construction is the same as in Figure 1. Corresponding vectors to ZY and Z'Y are C'Y' and C'Y'', respectively. Because both vectors C'Y' and C'Y'' start from point C', and due to the order of KL ratio between ZY and Z'Y, point Y'' always lies more inside the isocost line ACD than point Y'. This indicates that a large KL gap fragmentation leads to more total cost reduction than a small gap fragmentation.

=== Figure 3 ===

## 2.2. Service Link Costs

So far, we have not considered costs to link two remotely located fragments, i.e.

[3] If the fragment ZY is not so labor-intensive, that is, if Y' is placed on the upper-left area of the point C, international fragmentation raises the total cost. In this paper, we assume that the fragment ZY is sufficiently labor-intensive. At the same time, the fragment OZ is assumed to be sufficiently capital-intensive that the good X is capital-intensive enough to be produced only in the North in the unfragmented technology.

[4] Since allowing the dependence of the cost in the capital-intensive fragment on its KL ratio prevents us from visualizing our claim, we do not cover such fragmentation in this paper.

service link costs. A service link would require additional supervision, coordination, and control over the geographically diversified production activities. In this subsection, we model such costs as additional factor use. As a result, international fragmentation is required to use more combined factors than could have produced the good before. Specifically, we assume that such extra resources have the same KL ratio with the fragment at home and are inputted at home by a certain proportion of resources used in the home fragment.[5] This type of fragmentation is qualitatively similar to the one that Deardorff (2001) calls "costly fragmentation".

In this framework, as in Deardorff (2001), we can see that international "costly" fragmentation could still lead to a total cost reduction. Such a case is shown in Figure 4. Since the capital-intensive fragment extends beyond the previous isocost line B'C'E', the labor-intensive fragment's vector also reaches beyond the unit-isocost line BCE. As a result, the same figure construction as before yields the point Y', through which an isocost line shows the total cost in international fragmentation. Thus, international fragmentation can reduce the total cost even though it is costly in terms of factor use. Consequently, as the fragmentation theory claims (see, for example, Arndt and Kierzkowski, 2001; Cheng and Kierzkowski, 2001), whether international fragmentation reduces total cost or not depends on the magnitude of service link costs (in our case, the amount of the extra resources). The longer the vector OZ, the more likely it is that point Y' will reach the right area of unit-isocost line ACD. Thus, the smaller the service link cost, the larger total cost reduction the firms can enjoy.

=== Figure 4 ===

We again compare fragmentation between large and small KL gaps, incorporating service link costs. As shown in Figure 5, the figure construction is basically the same as in Figure 3. We extend the fragment OZ' by the same proportion as in the case of fragment OZ. Since we restrict ourselves to the fragmentation in which the cost for producing the capital-intensive fragment does not depend on its KL ratio, the vectors C''Y' and C''Y'' again start from the same point. Thus, we can confirm that a large KL gap fragmentation leads to more total cost reduction than a small gap fragmentation. Consequently, in this section, we obtain the following testable hypothesis:

**Testable Hypothesis:** *The larger the gap in KL ratios between a Northern fragment and*

[5] The following results are qualitatively unchanged even if we assume such extra resources are inputted abroad (see Deardorff, 2001), or both at home and abroad.

*a Southern fragment, the greater the total cost reduction in international fragmentation.*

In other words, the larger the gap in KL ratios between an MNE's home and overseas activities, the larger its total profit is. As long as we assume Leontief technology, the MNE's profit has a positive linear relationship with the gap in KL ratios. From the next section, we investigate whether this hypothesis is empirically valid or not.

=== Figure 5 ===

## 3. Empirical Issues

### 3.1. Methodology

Our hypothesis to be tested is whether the larger the gap in KL ratios between a fragmentation firm's home and overseas activities, the better the performance of the firm is. To empirically test this hypothesis, we regress the following simple linear equation:

$$Performance_{ft} = \beta_0 + \beta_1 Gap_{ft} + u_{ft},$$
$$\text{where} \quad Gap_{ft} = (K_{ft}^{\text{Home}} / L_{ft}^{\text{Home}}) - (K_{ft}^{\text{Abroad}} / L_{ft}^{\text{Abroad}}).$$

$\beta_0$ and $\beta_1$ are coefficients to be estimated, and $\beta_1$ is expected to be significantly positive. $u$ is disturbance. *Gap* is the difference in capital-labor ratios between home and abroad.[6] $K$ and $L$ are tangible fixed assets and labor, respectively. Subscripts $f$ and $t$ represent firm and year, respectively. We do not take logs of *Performance* and *Gap* not only because they can be negative but also because the theoretical framework does not require us to take their logs. To keep consistency of our empirical framework with the above theoretical prediction, we investigate MNEs' profits on a consolidated basis, i.e. the sum of home profit and overseas profit.[7] Thus the greater the total cost reduction in

[6] In this paper, we use the *difference* in capital-labor ratios between home and abroad rather than their *ratio*. In the gravity analysis, the relationship between trade and wage gap is often examined (see, for example, Kimura, et al., 2007). All these studies use a *difference* in GDP per capita between exporter and importer as the gap measure. Also in the studies of the knowledge-capital model, e.g. Carr, et al. (2001), a *difference* in the share of the labor force in certain skilled occupations between parent and host country is used in order to examine the relationship between affiliate sales and skill difference. Our paper follows the formulation of gap in such studies. But, even in the case of the *ratio*, we obtain qualitatively the same results, particularly in the case of labor productivity.

[7] To our best knowledge, this paper is the first that explores the impacts of investing abroad on investors' consolidated performance.

international fragmentation, the larger their consolidated profits would be. To control differences in scale among MNEs, we divide the consolidated profits by their total assets. In addition to the profits, we also examine the impact on value added[8] on a consolidated basis, which is further divided by their total employment. Firms with greater total cost reduction in international fragmentation would gain larger value added. In sum, our performance measures are return on assets (ROA) and labor productivity on a consolidated basis.

Some other variables are included as independent variables for controlling firm-specific characteristics and host country-specific characteristics. The first variable is a firm-specific one. The amount of capital stock on a consolidated basis is included to further control MNEs' scale. The other variables are host country-specific ones. In the above theoretical framework, we confirm that the smaller the service link cost, the larger the benefit from investing. To control differences in the service link cost with Japan among host countries, we include two variables on such cost: geographical distance between Japan and host country and the extent of country risk. As a result, our baseline regression equation is given by

$$Performance_{ft} = \beta_0 + \beta_1 Gap_{ft} + \beta_2 \ln Capital\ Stock_{ft} + \beta_3 \ln Distance_c + \beta_4 \ln Risk_{ct} + u_{ft}.$$

Subscript $c$ represents host country. Year and industry dummies are also introduced.

In order to keep further consistency with the theoretical framework, we need to restrict our sample firms only to firms with fragmentation. To do that, we require sample firms to meet the following five conditions. The first is to invest in East Asian countries since many empirical papers such as Kimura (2006) show that Japan has actively been engaged in international fragmentation primarily with East Asian countries. Secondly, we restrict to firms with only one affiliate. Although it is an important research topic to clarify the mechanics and consequences of operating multiple affiliates, such examination is beyond our framework in section 2.[9] The third is the firms of which activities at home are more capital-intensive than those abroad. Since Japan is expected to serve as a country producing the more capital-intensive fragments

[8] Due to the data limitation in this paper, value added is simply defined as total sales minus total procurements.

[9] We also conducted regression with the MNEs with multiple affiliates in East Asia. The gap measure is constructed by using the weighted average of all East Asian affiliates' KL ratio in each MNE. We use affiliates' sales as a weight. Their inclusion in the sample drastically increases the number of observations in regression, though the aggregation procedure is inevitably accompanied by a looser link with our theoretical framework. As a result, we obtained qualitatively unchanged results as reported in this paper.

than host countries in East Asia, firms with negative gaps are eliminated from our sample. Fourthly, we restrict our sample set to firms that are actually exporting their products from home to their overseas affiliates, since the fundamental source of benefits from international fragmentation is the intra-firm vertical division of labor between home and abroad. As long as we assume that upstream processes are more capital-intensive, Japanese MNEs should export their upstream products to their affiliate. Lastly, our sample of overseas affiliates is restricted to affiliates in the same industry as their parents, which enables us to compare KL ratios among fragments (production processes) in an industry, as is consistent with our theoretical framework.

## 3.2. Data Issues

Our main data source is "The Basic Survey of Overseas Business and Activities (BSOBA)," which is a firm-level survey by the Ministry of Economy, Trade and Industry, Government of Japan. The aim of this survey is to obtain basic information on the activities of the overseas affiliates of Japanese firms. The survey has two versions. One is the Basic Survey, which includes more detailed questions and is conducted every three years. The other is the Trend Survey, which is an abbreviated version and is carried out between the Basic Surveys. Both the Basic Survey and the Trend Survey consist of two parts: one is for parent companies and the other is for their overseas affiliates.[10] The parent companies are Japanese corporations which, as of the end of March, own or have owned overseas affiliates in the past, excluding those in the financial and insurance industry or real estate industry. The information on parents includes their employment, assets, exports, and so on. As for affiliates, the establishment year of the affiliates, the breakdown of sales and purchases, employment, costs, and research and development, and so forth are available. As a result, the BSOBA provides us all necessary data on firm-specific variables.

As of 2008, micro data sets for the BSOBA are available between 1995 and 2005. However, tangible fixed assets in parent firms and their overseas affiliates, which are necessary to construct the Gap, are available only in the Basic Survey. Furthermore, such information turns out to be unavailable for 2004. Thus, our sample years are forced to be only 1995, 1998, and 2001. For further information on the figures included in the BSOBA, see "Survey Form for Oversea Affiliates" and "Guide for Completing the

[10] An overseas affiliate of a Japanese firm is defined as follows: a foreign affiliate in which a Japanese firm has the invested capital of 10% or more, a foreign affiliate in which a "subsidiary" funded more than 50% by a Japanese firm has invested capital of more than 50%, and a foreign affiliate in which a Japanese firm and a subsidiary funded more than 50% by a Japanese firm have invested capital of more than 50%.

Survey".[11]

Next, data sources of the country-specific variables are as follows: the data on bilateral distance are drawn from the CEPII website. As a proxy for the country risk, we use a country risk index which is drawn from Institutional Investor (Institutional Investor, various issues). This index is formed from aggregates of bankers' evaluations on the risk of default, and a larger value indicates that the risk of default in the country is smaller.

Lastly, it is worth noting one crucial limitation in our dataset. Our dataset is pooling data, not panel data. Although our data source includes firm identification codes applicable over years, most of our sample firms appear only once, mainly due to the frequent absence of data on tangible fixed assets. As a result, we are forced to treat our sample as a pooling set and could not introduce time-invariant firm-fixed effects into our regression equation.

## 4. Empirical Results

### 4.1. Overview of KL Ratios in Japanese MNEs

We present some tables on capital-labor ratios in Japanese MNEs in 1998, in which there are a largest number of observations for our sample period, i.e. 1995, 1998, and 2001. The number of Japanese overseas affiliates reporting both K and L in 1998 is provided by industry by region in Table 1.[12] As for regional definition, in this paper, East Asia means ASEAN countries, China, and Asian NIEs, while developed countries include European countries (both Western and Eastern European countries) plus North American countries (Canada and the US).

=== Table 1 ===

Three kinds of measures are presented. The first is the simple average of KL ratios in Japanese affiliates. In most of the industries, affiliates in developed countries have higher KL ratios than those in East Asian countries. This result implies that Japanese MNEs investing in East Asia aim to utilize low-priced labor. Secondly, the simple average of KL ratios in Japanese MNEs' home activities is also presented.

[11] Downloadable from the METI web site:
http://www.meti.go.jp/english/statistics/tyo/kaigaizi/index.html.

[12] This table includes the MNEs with multiple-affiliate or/and negative gap values and those without exports to their affiliates.

Compared with the results in the first measure, the table does not show clear differences in KL ratios between the case of East Asia and that of developed countries, in most of the industries. This result would indicate that Japanese MNEs investing in either East Asia or developed countries have no choice but to get engaged in sufficiently capital-intensive production activities at home due to the high wages in Japan. The last is the gap in KL ratios between home and overseas activities. We find that, in almost all industries, the gap is larger in the case of East Asian countries. Thus, we can say that, on average, Japanese MNEs investing in East Asia cut out production blocks on the basis of factor intensities.

## 4.2. Regression Results

Next, we report our regression results. Basic statistics are provided in Table 2.[13] Table 3 tabulates the regression results.

=== Tables 2-3 ===

The baseline results are presented in equation (I). Three points are noteworthy in the case of ROA. First, we can see that the coefficient for Gap is estimated to be significantly positive at the five percent level, indicating that the larger the gap in KL ratios between MNEs' home and overseas activities, the higher their profitability. Secondly, the insignificant result in capital stock would be because differences in scale among MNEs are already adjusted by dividing their consolidated profits by their total assets. Thirdly, as is consistent with our theoretical framework, the closer to Japan the host country is, that is, the lower the distance-related charge, the significantly better the performance. The results in the case of labor productivity are basically the same as in the case of ROA. In particular, the coefficient for Gap is again positively significant at the one percent level. The noteworthy difference with the case of ROA is that the coefficient for the capital stock turns out to be significantly positive. This result may indicate that total employment is not enough to control MNEs' scale embodied by their capital stock, in contrast to total assets.

To confirm the robustness of these results in Gap, we further conduct several regressions. First, by introducing country fixed effects or country-year fixed effects, we control host country characteristics in full detail, which include factor endowment, technology, the magnitude of service link costs, and so on. Then, differences in factor

[13] In this dataset, we exclude two obvious outliers in gap: they have abnormally large gaps of a value greater than 1,000.

prices, that is, differences in the slope of the unit isocost line, are also controlled. In these regressions, host country-specific variables are dropped. Their results are reported in equations (II) and (III) and remained unchanged with baseline results. That is, we consistently find positive estimators of the Gap coefficient.

The second robustness check is more important. Since our sample of host countries comprises countries with different levels of economic development, there seem to be the large differences in labor quality. Although such differences may be partly controlled by introducing country-year fixed effects, we also try to adjust such differences more directly. Specifically, we multiply an affiliate's employment by a ratio of the level of education (average schooling years in the total population) in the host country to that in Japan. The data concerning the education level are drawn from "Data Set for a Panel of 138 Countries" provided by Robert J. Barro and Jong-Wha Lee.[14] By employing such adjusted labor in the host countries, we again calculate our gap measure and labor productivity. Their basic statistics are reported in Table 2, and the regression results are provided in Table 4. From this table, we again find qualitatively unchanged results compared with Table 3 and confirm the significantly positive coefficients for Gap.

=== Table 4 ===

## 5. Concluding Remarks

This paper empirically investigated gains from fragmentation at the firm level. Examining corporate performance on a consolidated basis, we investigated, using Japanese firm-level data, whether the heterogeneity in impacts of international fragmentation on corporate performance across firms exists or not. We found that the larger the gap in KL ratios between their home and overseas activities, the more greatly their cost efficiency improves. Several estimations confirmed the robustness of this finding. Given this finding, our future research may be to clarify what firm characteristics determine such a gap in KL ratios between home and overseas activities.

[14] http://www.nber.org/pub/barro.lee/

## References


Arndt, S. W. and Kierzkowski, H., 2001, *Fragmentation: New Production Patterns in the World Economy*, Oxford University Press, Oxford.

Athukorala, P.-C. and Yamashita, N., 2006, Production Fragmentation and Trade Integration: East Asia in a Global Context, *The North American Journal of Economics and Finance*, **17**(3): 233-256.

Carr, D., Markusen, J., and Maskus, K., 2001, Estimating the Knowledge-Capital Model of the Multinational Enterprise, *American Economic Review*, **91**: 693-708.

Cheng, L. K. and Kierzkowski, H., 2001, *Global Production and Trade in East Asia*, Kluwer Academic Publishers, Boston.

Deardorff, A., 2001, Fragmentation across Cones, In: SvenW. Arndt and Henryk Kierzkowski, eds., *Fragmentation: New Production Patterns in the World Economy*, Oxford University Press, pp. 35-51.

Kimura, F., 2006, International Production and Distribution Networks in East Asia: Eighteen Facts, Mechanics, and Policy Implication, *Asian Economic Policy Review*, **1**: 326-344.

Kimura, F. and Ando, M., 2005, Two-dimensional Fragmentation in East Asia: Conceptual Framework and Empirics, *International Review of Economics and Finance*, **14**(3): 317-348.

Kimura, F., Takahashi, Y., and Hayakawa, K., 2007, Fragmentation and Parts and Components Trade: Comparison between East Asia and Europe, *North American Journal of Economics and Finance*, **18**(1): 23-40.

Table 1. KL Ratios

| | Observations | | KL in affiliates | | KL at home | | Gap | |
|---|---|---|---|---|---|---|---|---|
| | Developed Countries | East Asia | Developed Countries | East Asia | Developed Countries | East Asia | Developed Countries | East Asia |
| Textile | 5 | 110 | 15 | 3 | 48 | 13 | 32 | 11 |
| Chemicals | 157 | 262 | 30 | 19 | 25 | 27 | -5 | 8 |
| Primary metal | 28 | 90 | 16 | 14 | 23 | 27 | 6 | 13 |
| Metals | 14 | 42 | 13 | 6 | 10 | 9 | -3 | 3 |
| General Mach. | 134 | 153 | 17 | 4 | 13 | 11 | -4 | 7 |
| Electrical Mach. | 48 | 138 | 11 | 6 | 11 | 10 | 0 | 5 |
| IT Mach. | 145 | 298 | 4 | 5 | 11 | 12 | 6 | 7 |
| Trasnport Equip. | 187 | 221 | 19 | 9 | 12 | 12 | -7 | 3 |
| Precision Mach. | 23 | 43 | 6 | 5 | 9 | 11 | 2 | 6 |
| Others | 176 | 347 | 20 | 23 | 24 | 22 | 4 | 0 |
| Total Average | 917 | 1,704 | 18 | 11 | 17 | 17 | -1 | 5 |

*Source*: Authors' calculation by using the Basic Survey of Overseas Business and Activities

Table 2. Basic Statistics

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Return on assets | 204 | 7 | 14 | -18 | 108 |
| Labor productivity | 204 | 13 | 19 | -23 | 145 |
| Gap | 204 | 9 | 16 | 0 | 198 |
| log of Capital stock | 204 | 6 | 2 | 3 | 10 |
| log of Distance | 204 | 8 | 1 | 7 | 9 |
| log of Country risk | 204 | 4.06 | 0.26 | 3.33 | 4.42 |
| Adjusted Labor productivity | 204 | 8 | 16 | -4 | 197 |
| Adjusted Gap | 204 | 13 | 19 | -23 | 144 |

*Source*: Authors' calculation by using the Basic Survey of Overseas Business and Activities

Table 3. Baseline Results

| Dependent variable | Return on Assets | | | Labor Productivity | | |
|---|---|---|---|---|---|---|
| Equation | (I) | (II) | (III) | (I) | (II) | (III) |
| Gap | 0.108** | 0.117* | 0.121* | 0.495*** | 0.450*** | 0.457*** |
| | [0.054] | [0.062] | [0.063] | [0.095] | [0.096] | [0.100] |
| log of Capital stock | -0.249 | -0.376 | -0.570 | 2.379*** | 2.632*** | 2.619*** |
| | [0.748] | [0.697] | [0.747] | [0.613] | [0.632] | [0.690] |
| log of Distance | -6.414** | | | -4.745 | | |
| | [2.989] | | | [3.175] | | |
| log of Country risk | -3.127 | | | -1.477 | | |
| | [3.123] | | | [5.167] | | |
| Year dum. | YES | YES | NO | YES | YES | NO |
| Industry dum. | YES | YES | YES | YES | YES | YES |
| Country dum. | NO | YES | NO | NO | YES | NO |
| Country*Year dum. | NO | NO | YES | NO | NO | YES |
| Observations | 204 | 204 | 204 | 204 | 204 | 204 |
| R-squared | 0.188 | 0.206 | 0.250 | 0.425 | 0.498 | 0.505 |

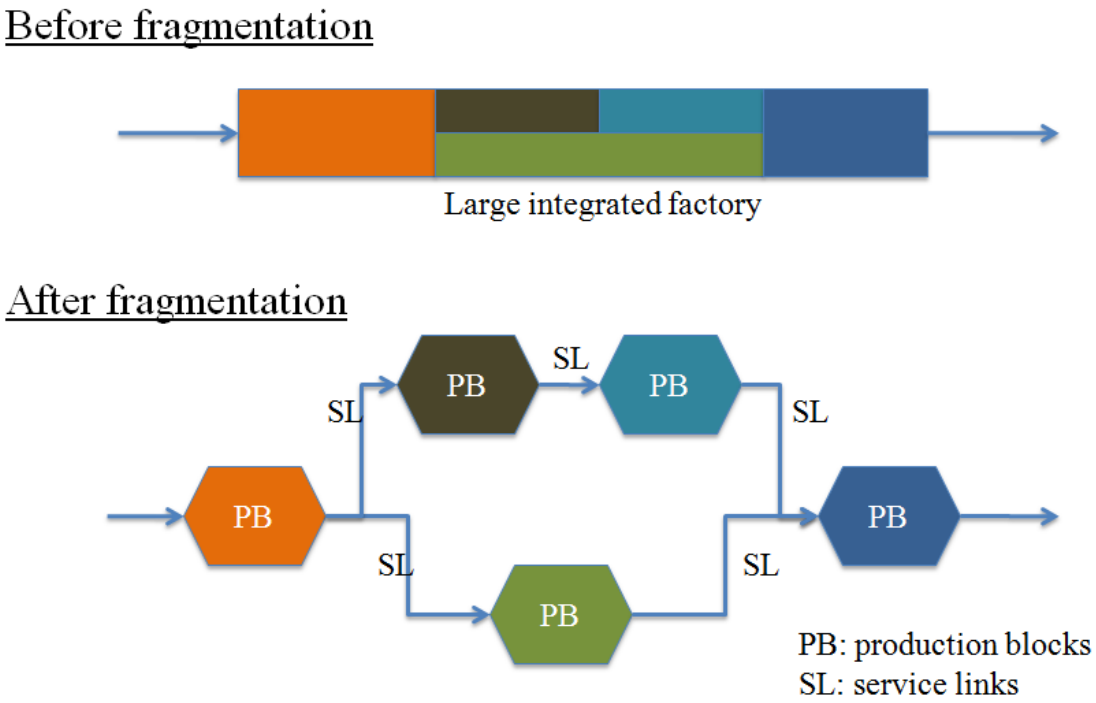
*Notes*: Heteroskedasticity-consistent standard errors (White) are in parentheses. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Table 4. Regression Results: Adjusted Employments

| Dependent variable | Return on Assets | | | Labor Productivity | | |
|---|---|---|---|---|---|---|
| Equation | (I) | (II) | (III) | (I) | (II) | (III) |
| Gap | 0.113** | 0.119* | 0.123* | 0.545*** | 0.500*** | 0.509*** |
| | [0.055] | [0.063] | [0.064] | [0.093] | [0.097] | [0.102] |
| log of Capital stock | -0.226 | -0.349 | -0.539 | 2.511*** | 2.707*** | 2.696*** |
| | [0.750] | [0.698] | [0.745] | [0.593] | [0.620] | [0.674] |
| log of Distance | -6.384** | | | -3.882 | | |
| | [2.974] | | | [3.181] | | |
| log of Country risk | -3.253 | | | -3.326 | | |
| | [3.107] | | | [5.215] | | |
| Year dum. | YES | YES | NO | YES | YES | NO |
| Industry dum. | YES | YES | YES | YES | YES | YES |
| Country dum. | NO | YES | NO | NO | YES | NO |
| Country*Year dum. | NO | NO | YES | NO | NO | YES |
| Observations | 204 | 204 | 204 | 204 | 204 | 204 |
| R-squared | 0.189 | 0.207 | 0.251 | 0.448 | 0.509 | 0.517 |

*Notes*: Heteroskedasticity-consistent standard errors (White) are in parentheses. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Figure 1. The Fragmentation Theory: Production Blocks and Service Links




*Source*: Authors' compilation

Figure 2. Fragmentation

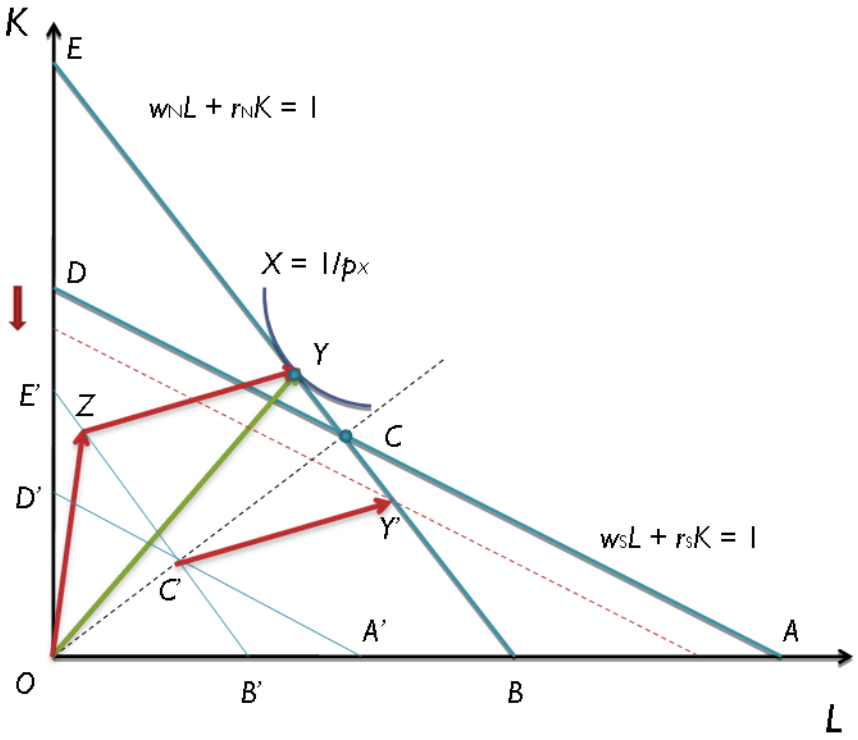



Figure 3. Small KL Gap versus Large KL Gap

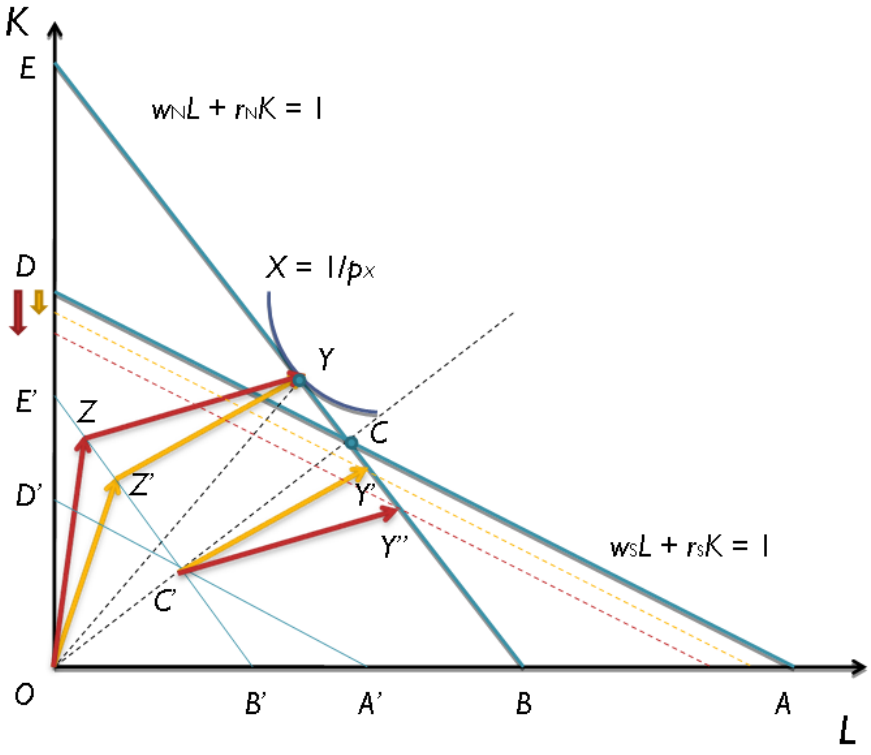


Figure 4. International Fragmentation with Service Link Costs

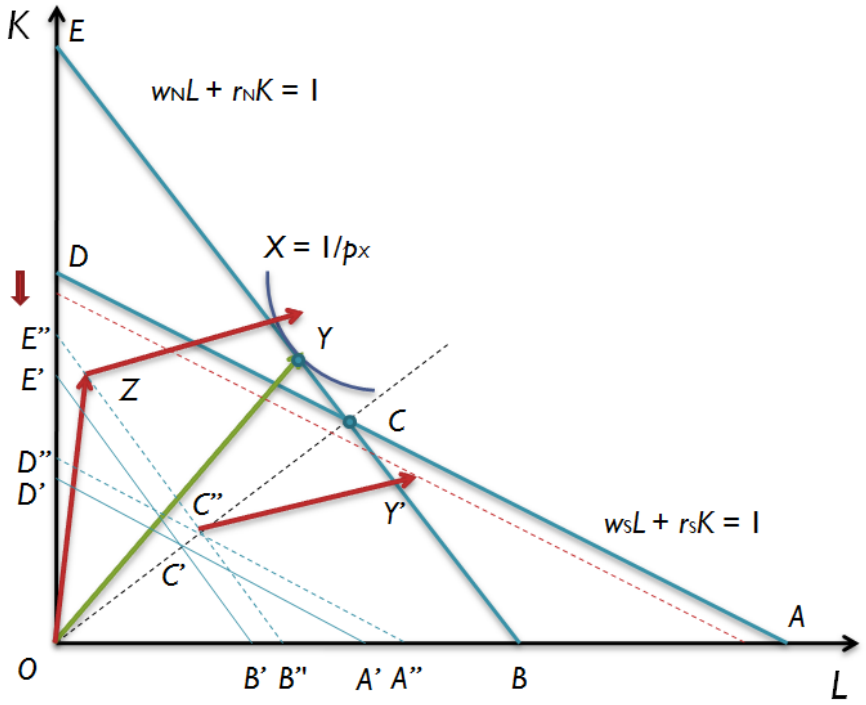



Figure 5. Small KL Gap versus Large KL Gap: Service Link Costs