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DISCUSSION PAPER No. 315

Production Networks in the Asia-Pacific Region: Facts and Policy Implications

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Abstract

Production networks have been extensively developed in the Asia-Pacific region. This paper employs two micro-level approaches, case studies and econometric analysis, using JETRO's firm surveys which investigate Japanese affiliates operating in Southeast Asia. These two approaches found that production networks have extended, involving suppliers, across various nations in the Asia-Pacific region, and that production bases in host and home countries have different roles. A home country serves as a headquarters with services such as R&D, international marketing, and financing. A high tariff policy in a host country may foster domestic industries through the expansion of procurement from domestic suppliers, either indigenous or foreign, but it may discourage a country from becoming an export platform.

Keywords: skilled differentiation, high tariff policy, export-platform FDI
JEL classification: F14, F15, F23

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1. INTRODUCTION[1]

In the last two decades, intermediate trade or input trade has grown at a much faster rate than other types of goods in world trade and is considered an important factor for explaining the recent high growth in world trade. According to Freenstra (1998), the increasing integration of the world's markets has brought with it a disintegration of the production process, meaning assemblers are finding it profitable to outsource increasing amounts of the production process, either domestically or internationally. Nowadays, production is fragmented and fragmented production blocks are dispersed mainly in neighboring countries. Thus, intermediate trade has increased remarkably.

East Asia, in particular, has developed the most international production networks in the world (Ando and Kimura, 2003). With the rapid increase in intermediate trade, the investigation of international production networks is an important research topic for the region.

For this purpose, Section 2 of this paper briefly reviews the past theoretical and empirical studies on production networks. Section 3 investigates production networks by looking at the procurements of the hard disk drive (HDD) and automobile industries as case studies. The HDD industry provides an insight into how international production networks work in an integrated market where transportation costs are extremely low. The HDD assembly industry in ASEAN is an export platform where affiliates produce goods mainly for export. On the other hand, the automobile industry in ASEAN has targeted domestic markets, but, due to the ASEAN Free Trade Area (AFTA), it is growing as a region-wide industry. This section pays attention to the role of logistics in facilitating domestic and international production networks. Section 4 empirically investigates the sales and procurements of Japanese affiliates by destination and by origin (host countries, home country and third countries) by using the results of JETRO's firm surveys that investigate Japanese affiliates operating in Southeast Asia. It is found that the year an operation starts is negative for sales and procurement from the home country (Japan) and third countries but positive for the sales and procurement of a host country. These facts when combined indicate that trade first begins between a host country and a home country which imports intermediate goods from the home country then, after processing, the goods are exported back to the home country.

[1] This paper was prepared for the Asia Pacific Study Centers Consortium (ASCC) Conference in San Francisco, California, September 22-23, 2011.

2. LITERATURE ON PRODUCTION NETWORKS

To understand the formation of international production networks, new economic geography and fragmentation theory are extremely useful concepts.

The first concept, new economic geography, attempts to explain the agglomeration and dispersion of economic activities in geographical space. The spatial structure of economic activities is considered to be the outcome of a process involving the opposing forces of agglomeration and dispersion. New economic theory analyzes the balance of these two opposing forces which results in a variety of locational patterns of economic activities.

Krugman (1991) explains how agglomeration forces emerge using a core/periphery model where, when transportation costs are low, a country becomes differentiated into an industrialized core and an agricultural periphery, with labor freely moving between regions. In other words, manufacturing firms tend to locate in regions of high demand when transportation costs are low. In the context of production networks, this means that interconnected firms and their supporting industries become geographically clustered in a single region. An important factor that affects the core/periphery structure is the constant elasticity of substitution. If the constant elasticity of substitution is low, that is, if a good is highly differentiated, the core and periphery emerge easily. On the other hand, if the constant elasticity of substitution is high, or a product is less differentiated, the core and periphery do not emerge. For instance, bakeries are usually geographically dispersed due to a low degree of differentiation, while manufacturing tends to concentrate in one area because of a high degree of differentiation. Agglomeration forces are, therefore, largely dependent on both transportation costs and the degree of differentiation in the goods.

Agglomeration forces also generate dispersion forces due to congestion in the labor and property markets. Krugman and Venables (1995) extended Krugman's original model (1991) in which labor cannot move between regions and concluded that manufacturing moves from the industrialized and innovating country (the core) to the non-industrialized and non-innovating country (the periphery). Initial decreases in transportation costs cause the economy to organize itself into an industrialized core and a de-industrialized periphery. However, if transportation costs fall enough for the advantage of low wages in the periphery to offset the disadvantage of it being remote from its markets and suppliers, manufacturing in the core will move to the periphery. Dispersion forces depend on the relative labor costs of the core and peripheral countries as well as the degree of differentiation in the goods. For goods that are not well-differentiated dispersion forces emerge early.

A key property of agglomeration forces resides in the circular causality of economic activities. For example, if an automobile assembler attracts a number of upstream suppliers to the same region, the resulting productivity enhancement and market expansion might also attract other automobile assemblers. Such circular causality generates not only agglomeration forces but also dispersion forces. The concentration of economic activities raises land prices and wage rates, resulting in severe price competition between firms. Traffic congestion, difficulties in telecommunication, and air pollution also increase. These congestion effects intensify dispersion forces, enabling the periphery to take advantage by attracting economic activities. One important factor that subtly affects the balance between agglomeration and dispersion is the cost of transport, which includes freight costs, tariffs, non-tariff barriers, and the risk of exchange-rate variations.

The second useful concept for understanding the formation of international production networks is fragmentation theory. Fragmentation theory focuses on the location of production processes. It suggests that production processes should be fragmented into several stages with separate production blocks being located at different sites, either domestic or international. By dividing the production process into separate blocks and by situating each block in the most appropriate location, the total cost of production can be reduced. Production fragmentation has been discussed by many authors (Jones and Kierzkowski 1990; Deardroff 2001; and Yi 2003). Deardroff (2001) claims that the incentives for fragmentation are larger when fragmentation is applied across different countries due to differences in factor prices and the availability of technology, and that the service costs of international fragmentation are larger if regulations and restrictions impede the international provision of services. Deardroff (2001) contains important policy implications in the context of economic development. If service link costs and network set-up costs are reduced, production can be fragmented. As a result, large disparities in factor prices can be transformed into a dynamic economy. Yi (2003) verifies that high tariffs prevent vertical specialization, while low tariffs enable vertical specialization. This means that reductions in service link costs are essential for further production fragmentation. The border effect is very large in vertical specialization because tariffs impose two taxes on the first stage of production for only one fragmentation—once when the first-stage good enters the foreign country and again when the second-stage good is imported back to the home country.

One possible interpretation of the combination of new economic geography and fragmentation theory is that when transportation costs are low, production can fragment, and that while fragmented production blocks tend to concentrate in one region within a country, they eventually disperse throughout neighboring countries. However, few

studies have examined location with respect to geography. Hillberry and Hummels (2005) tracked manufacturers' shipments within the United States (US) and concluded that the number of shipments rapidly declines with distance, dropping off almost by an entire order of magnitude between one- and two-hundred miles, and being nearly flat thereafter. They also found that the price of shipments sharply rises over distance, while the average shipment weight falls. The study suggests that most goods are shipped only to geographically proximate customers, with only high unit-value goods being shipped to geographically distant customers. Hillberry and Hummels (2005) also verified that industry tends to cluster within a limited area of 200 miles.

Why are there such differences between Japanese and American affiliates? Helpman (2002) explained that the extent of international outsourcing depends on the depth of the domestic and foreign markets for input suppliers, the cost of researching suppliers, and the cost of customizing inputs. Applying Helpman (2002), the difference in behavior between Japanese and American affiliates can be interpreted by seeing that the cost of researching suppliers by American affiliates is lower than that for the Japanese. American affiliates that have employed local managers can source indigenous suppliers through local networks and reduce the cost of researching suppliers, while Japanese affiliates, whose managers are often Japanese, are unable to reduce costs in the same way.

Empirical studies have been conducted on fragmenting production across different countries. Hummels, Ishii, and Yi (2001) assessed the degree of vertical specialization in the Organisation for Economic Co-operation and Development countries by using input–output tables. They used the imported contents of exports as an index of vertical specialization. Hanson, Mataloni, and Slaughter (2003) examined vertical specialization in US multinational firms and their host countries, and showed that low transportation costs, low wage levels for unskilled labor, and a low corporate tax rate all had a positive influence on vertical specialization between the home country and the host countries.

As for international production networks in East Asia, Ando and Kimura (2003) addressed the fact that production networks in the machinery industry have developed more in East Asia than in other regions. Ando and Kimura (2008) suggest that the spatial microstructure of vertical production chains effectively combines intra-firm and arm's-length transactions where the parties in a transaction are independent and on an equal footing. The development of arm's-length transactions and the formation of an agglomeration form a mutually enhancing causal link. Kimura (2010) stratified the procurement of parts and components and the sales of products into four layers in terms of gate-to-gate lead-time and delivery frequency: local, sub-regional, regional, and world. Ozeki (2009) found that the share of international input from Japan of total input

tends to decrease for the automobile industry, while the share of international input is stable for the electronics industry. Hiratsuka (2006 and 2011) found that a hard disc drive manufacturer operating in Thailand procured parts from many overseas suppliers, mostly from neighboring countries based on arm's length trade. Hiratsuka (2008) found that even a small country like Laos participated in production networks. Hiratsuka (2010) investigated the trade patterns of 14 East Asia countries and obtained the estimated results that Extra-14 East Asia is more sensitive to geographical distance than intra-14 East Asia and that finished goods are more sensitive to distance in extra-14 East Asia but not in intra-14 East Asia.

Hayakawa and Matsuura (2009 and 2010) categorized foreign direct investment (FDI) into three basic types: 1) horizontal FDI (the setting up of plants within the target market/country rather than exporting from the home country), 2) vertical FDI (affiliates engaging in a labor-intensive process by inputting capital-intensive parts and components supplied by the home headquarters), and 3) export-platform FDI (affiliates serving third markets by exporting final goods). These three types of FDI were further categorized into a total of seven types of FDI according to their sales and procurement destinations. In terms of affiliate numbers, in opposition to the theoretical literature in which horizontal FDI prevails, export-platform FDI holds the largest share for Japanese multi-national affiliates, particularly in the textiles and precision machinery industries. Furthermore, complex vertical-FDI, in which a parent country invests in a particular host country with the intention of serving third markets with exports of final goods from an affiliate in the host country, and of procuring from third countries, accounts for a large share in the electronics, information and technology, and precision machinery industries. These observations are consistent with the study by Ando and Kimura (2003) that Japanese firms have played an important role in developing vertical production networks in the region.

3. CHARACTERISTICS AND FEATURES OF PRODUCTION NETWORKS

This section aims to see how production networks have operated? For this purpose, first, the actual procurement of an HDD assembling factory and an automobile assembling factory are examined as case studies. Then, the logistic networks, which link each separated production block in order to produce a final product, are examined.

3.1. Production Networks in the HDD Industry

3.1.1. Why the HDD industry?

HDDs are compact and light, so their transportation costs are quite low. Thus HDDs provide an example of what can happen in the location of an industry if economies are fully integrated. Indeed, each main component of HDD is divided into many processes, and separate processes are outsourced to different suppliers across countries. The HDD industry, therefore, has a hierarchical tree structure composed of upstream processes (research and development and high-tech wafer processes) and downstream processes (final assembly, component and parts procurement). This hierarchical tree structure, which consists of different firms in different countries, has enabled the HDD industry both to attain economies of scale in the economics of short-life products and to distribute the costs of investment among assemblers, component suppliers and parts suppliers.

Research and development, including the design of HDDs, and the high-tech wafer fabrication processes, are conducted in the home countries of multinational enterprises, but most of the production processes and final assembly have been operating in East Asia, particularly in Southeast Asia and, more recently, in PRC. (Diagram 1 shows the distribution of HDD assemblers in East Asia.1).

3.1.2. Procurement of an HDD Assembler

Diagrams 2 and 3 show the procurement sources in 2005 of Hitachi Global Storage (HGST) in HGST Thailand and HGST Singapore which produce HDDs for PCs in Thailand and for servers in Singapore, respectively. There are several notable features (Hiratsuka, 2006 and 2011).

First, the two factories procured components and parts from a number of places (Indonesia; Hong Kong, China; Japan; Malaysia; Mexico; the Philippines; the PRC; Taipei; and the US). In terms of the number of suppliers, procurement from overseas suppliers surpassed procurement from domestic suppliers.

Second, most suppliers are arm's-length suppliers located in ASEAN neighboring countries. This close proximity makes it possible not only to provide overnight delivery services to customers but also to minimize losses incurred from defective units. In other words, a location close to customers is necessary for lower transportation and communication costs. International production networks, therefore, tend to be concentrated within a limited economic space.

Third, core components, on the other hand, were procured through intra-firm trade. HGST's head office in San Jose, USA produces silicon wafers for HDD heads and

suspension. HGST Mexico fabricates thin chip sliders from the wafers. Heads and suspension made in the US and thin chip sliders fabricated in Mexico are sent to HGST in East Asia for assembly into Head Gimbal Assemblies (HGA) and Head Stacked Assemblies (HSA)[2]. The HGST group is engaged in producing the core components of the head-related core components.

Lastly, the two factories procured the same parts from multiple suppliers located in different countries. HGST Thailand procured media from Japan (Hoya), Malaysia (Komag), PRC (HGST), Singapore (Hoya), and the US (HGST). Printed circuit boards were procured from Indonesia (Solectron), Japan (Bridgestone), the Philippines (Ionix), PRC (Global Brands Manufacture and Sanmina-SCI), and Thailand (Sanmina-SCI). Pivots were procured from Malaysia and Singapore (NSK) and Thailand (MNB). Voice coils were procured from Indonesia and Malaysia (Shinetsu) and Thailand (SMT and TDK). It should be noted that HGST Thailand procured the same components and parts not only from domestic suppliers but also from overseas suppliers, and procured them from inter-firms rather than intra-firms. There are several reasons for the procurement of the same components and parts from multiple suppliers. Outsourcing to multiple suppliers encourages competition between suppliers, and more importantly, it reduces the risk of issues arising from components being unavailable due to accidents or political incidents.

3.2. Production Networks in the Automobile Industry

3.2.1. High procurement ratio from local suppliers

Procurement in the automobile industry is quite different from the HDD industry. First, there are large differences in the local procurement/overseas procurement ratio. The local content of a vehicle is approaching 100% in Thailand while the content of an HDD is about 50% (Kohpaiboon and Poapongsakorn, 2009). Their views are consistent with studies that used the local share of sales of Japanese affiliates operating in Asia in the "Basic Survey on Overseas Business Activities", which is an annual survey conducted by the Ministry of Economy, Trade and Industry (METI), Japan. Indeed, Ozeki (2008) made two interesting observations. One is that the ratio of local to total procurement differed across industries (about 30% for electronics but almost 70% for automobiles). Another is that the local procurement ratio is rising for the automobile industry but is flat over time for the electronics industry while for Asia it is rising for the

[2] HGAs are composed of a head and suspension, and HSAs are attached to an actuator with HGAs.

electronics industry. The fact that the local procurement ratio of the automobile industry is rising suggests that supporting industries for automobiles have greatly developed in Thailand and that assemblers are keen to reduce transportation costs by procuring inputs from suppliers in the local market.

3.2.2. Key parts from Japan to third countries

The automobile industry is a typical horizontal multinational pattern which produces the same final product in multiple locations, substituting international production for trade (Markusen, 1984). For example, Toyota has multiple automobile production plants in East Asia: seven automobile and parts production plants in China, four plants in Thailand, two plants in India, and one plant each in Indonesia, Malaysia, and the Philippines. Major multinationals have multiple plants in East Asia. Automobile assemblers operating in ASEAN and China have procured most of their parts and components from domestic suppliers in host countries but they get their key parts such as engines and transmissions from the parent's country.

This style of procurement is now changing to a new one in which automobile assemblers tend to procure key parts from affiliate plants in other countries as much as possible. Diagram 4 shows the complementary components operation of a Japanese automobile maker operating in ASEAN.

The ASEAN Free Trade Area (AFTA), where tariffs on manufactured goods were reduced to less than 5% in 2003, gives incentives for Japanese automobile assemblers to procure key parts from first-tier suppliers located in four ASEAN countries. As shown in Diagram 4, affiliate assemblers operating in the four countries import cylinder head assemblies, cylinder blocks, engine valves, steering wheels and automatic transmissions from Indonesia; instrumental panel assemblies, bumpers and drive shafts from Malaysia; engine fuel systems, emission dress parts, engine electronic parts, suspension parts, and manual transmissions from the Philippines; and press parts, frame panels, electronic parts, interior parts and engine parts from Thailand.

3.3. Logistic Systems to Facilitate Production Networks

3.3.1. The JIT warehouse logistics system

A logistics system, which links separated production blocks within a country and across countries for a product, is well-designed and plays a kind of infrastructural role for the development of production networks.

Components and parts for HDD assembly are procured not only from domestic suppliers but also from many overseas suppliers. So, how are these procured components and parts delivered to the assembler? HGST Thailand has employed the so-called “just in time” (JIT) warehouse system to meet its logistic needs in a system where many components and parts are supplied from overseas. The “JIT warehouse system” is designed to provide services for the delivery of intermediate goods from overseas suppliers. The arrival time at the airport varies from product to product because departure and arrival times are fixed by the air carrier. So, if many goods are procured from overseas, a warehouse is required for the storage of intermediate goods for “just in time” delivery. HGST Thailand has outsourced all its logistic services so that all the components and parts are picked up from suppliers, temporarily stored at the JIT warehouse near HGST Thailand, and finally provided just in time to the assembler. All the suppliers are therefore requested to use the logistics firm running the JIT warehouse. This firm and its affiliates pick up components and parts from the suppliers, either domestic or overseas, takes them to the warehouse, and then the components and parts are delivered from the warehouse to HGST Thailand for just in time production. Components and parts are regarded as delivery to HGST Thailand when they leave the JIT warehouse.

Components and parts are delivered from the JIT warehouse to HGST Thailand about four times a day. Components and parts are shipped once a day for domestic suppliers, and two or three times a week for overseas suppliers. The JIT warehouse, major suppliers and HGST Thailand are connected online, and suppliers can see the stock level of components and parts at the JIT warehouse. As for transportation costs, suppliers have to cover these costs between their factories and the JIT warehouse while HGST Thailand covers the JIT warehouse operation cost and cost between the JIT warehouse and HGST Thailand. This is quite different from the normal logistic where purchasers have to cover the cost between suppliers and their factories. The assembled HDDs are shipped to Singapore and then delivered to customers around the world.

3.3.2. A milk-run logistic system

By contrast, the automobile industry normally employs the milk-run logistic system, which suits a situation where most components and parts are procured from domestic suppliers located within a circle two-three hours away by truck. The milk-run system enables “just in time” services that connect an assembler with domestic suppliers. For this, the assembler outsources a logistics firm. The logistics firm arranges trucks to pick up components and parts at each factory and transports them to the

factories just in time. Either the JIT warehouse system or the milk-run logistic system helps to facilitate "jut in time" production as well as to reduce transportation costs.

4. EMPIRICAL ANALYSIS ON THE SALES AND PROCUREMENT BEHAVIOR OF JAPANESE AFFILIATES

What are the determinants of production networks? Which are relatively expanding, domestic production networks or international networks? To answer these questions, this section intends to investigate production networks at the firm level. Concretely, the sales and procurement of Japanese affiliates will be empirically analyzed by using the JETRO Survey of Japanese-Affiliated Firms in the ASEAN countries of Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam in 2006, 2007 and 2008.[3] For this, sales and procurement are classified into three groups: the host country, the home country (Japan) and a third country.

4.1. Japanese multinational enterprises in ASEAN

A major characteristic in international trade is the rapid expansion of intermediate trade or input trade. East Asia is the typical model where intermediate trade is growing rapidly in comparison to final goods. In the background of the expansion of intermediate trade, it should be noted that multinational enterprises have exported goods from a host country, where an affiliate is located, to a third country. Traditional thought is that multinational affiliates import input goods from their home country and, after processing, export them back to their home country. Hanson, Mataloni, and Slaughter (2003) showed that low transportation costs, low wage levels for unskilled labor, and a low corporate tax rate had a positive influence on vertical specialization between a home country and a host one.

Vertical trade between a host country and the home one is no longer just the concern of academics. It is also of great interest to policy makers. With the development of production networks, international trade between a host country and a third county has become a hot issue. Ekholm, Forslid, and Markusen (2007) proposed export-platform foreign direct investment (FDI): a parent country invests in a particular host country with the intention of serving "third" markets with exports of final goods from the affiliate in the host country (see Navaretti and Venables 2004). By using the

[3] JETRO conducted the survey of Japanese affiliates operating in Asia. See JETRO (2008).

"Basic Survey of Overseas Business and Activities" compiled by the Ministry of Economy, Trade and Industry (METI) of Japan[4], Hayakawa and Matsura (2010) classified FDI into three types according to their sales and procurement: 1) horizontal FDI where products are mostly sold in the host country; 2) vertical FDI where goods are produced in the host country and sold to the home country; and 3) export-platform FDI which sells goods to third countries. They found that export-platform FDI exceeded vertical FDI with sales ratios in 2001 of 66%, 9%, and 25% for all affiliates and 54%, 11% and 35% for affiliates located in ASEAN.

A similar result was obtained from our study based on the JETRO survey[5]. As summarized in Table 1, the number of firms where domestic sales were largest, defined as horizontal FDI, is 1003, 47% of the total. The share of horizontal FDI was 60% in Indonesia, 43% in Malaysia, and 65% in Thailand. Vertical FDI, where the largest proportion of sales is to the parent's country, namely Japan, was 471, 22% of the total number of firms. Vertical FDI appeared in Vietnam and accounted for 45% of Japanese affiliates in Vietnam. Export-platform FDI, where sales to third countries form the largest proportion of sales was found in 646 firms, about 30% of the total. Sales to third countries was the largest for 119 firms, 63% of whom were in Singapore, and for 152 firms, 39% of those in the Philippines.

4.2. The Sales and Procurement Behavior of Japanese Affiliates Operating in ASEAN

4.2.1. Knowledge capital model

Why were some countries still dominated by horizontal FDI (sales in the host country) and others by export-platform FDI (sales to third countries)? In what industry does export-platform FDI prevail? Why was vertical FDI dominant in Vietnam?

To investigate the determinants of the sales and procurement of affiliates by destination and origin, the knowledge capital model was employed. The knowledge capital model was theoretically proposed by Markusen (1997 and 2002) and empirically developed by Carr, Markusen, and Maskus (CMM, 2001), assuming that headquarters services, such as R&D, marketing, and financing, can be located in a relatively skilled labor abundant country, while manufacturing and assembly can be located in a relatively unskilled labor abundant country. Here, the following model is basically employed:

[4] The survey is a firm-level survey to obtain basic information of the activities of the overseas affiliates of Japanese firms.

[5] The survey used here includes a total of 2217 affiliates (323 in Indonesia; 374 in Malaysia; 188 in Singapore; 666 in Thailand; and 175 in Vietnam).

ln (*sales or procurement ratio*) = β_0 + β_1 (*absolute skill difference*) + β_2 *ln* (*GDP difference squared*) + β_3 *ln* (*trade cost host*)+ β_4 *ln* (*investment cost host*) + β_5 *ln* (distance *r*) + β_6 *ln* (*operation year*)

where the *sales (procurement) ratio* is the ratio of sales (procurement) by destination (origin) to total sales (total procurement). Sales and procurement are divided into three groups: the host country, the home country, and a third country. The operation year is the year the affiliate started its operations. The following data are obtained from the survey.

Absolute skill difference is the difference in the share of skilled labor between home and host countries in the case of a local sales ratio and a sales ratio to Japan, and between the host country and a third one in the case of a sales ratio to third countries. Skilled labor is regarded as workers in Occupational Group 1 (legislators, senior officials and managers), Group 2 (professionals), and Group 3 (technicians and associate professionals) from the International Standard Classification of Occupations, ILO statistics (see Table 2). The trade cost host is the average applied tariff on non-agricultural products of the host country (WTO). Investment cost host is the timedays that are officially required for an entrepreneur to start up and formally operate an industrial or commercial business (‘Doing Business’, the World Bank). The distance, denoting the geographical distance between capital cities (CEPII dataset), was incorporated for cases of sales to third countries and procurement from third countries. *ln* denotes a natural logarithm.

Tables 3, 4, and 5 summarize the estimated results of the ratio of sales in the host country, sales to Japan, and to third countries, to the total sale of affiliates. Also, Tables 6, 7, and 8 summarize the estimated results for procurement from the above. A third country refers to ASEAN, China, other Asia, the US, and others. Thus, the number of observations exceeds that of the responding affiliates as sales by destination or procurement by origin are all accounted for.

In addition to the estimated results of all responding firms, two kinds of robust checks were conducted. One is the estimation by industry. Machinery, automobiles, and electrical appliances & electronics were estimated. The other is the estimation by the year of the firm’s establishment. All the responding affiliates are divided into two: those established before 1991 and those established after 1992.

4.2.2. The difference in shares in skilled labor

The first explanatory variable, the difference in shares in skilled labor, showed a

positive sign with the local sales ratio, although it was not significant for automobiles. Similarly, it showed a positive sign with sales to third countries but was not significant for machinery, automobiles, and electrical appliances & electronics. The same results were obtained for procurement but were not robust.

These results indicate that Japanese affiliates allocate labor intensive production processes in ASEAN where unskilled labor is relatively abundant, leaving capital intensive headquarters functions in Japan where skilled labor is abundant. However, it is not clear whether the host and a third country have different roles in the production networks.

4.2.3. Differences in the size of the economy

The GDP difference between the host country and the home country showed a negative sign with local sales but a positive sign for sales to Japan and third countries. These observations mean that the larger the economy in the host country the greater the increase in the local sales ratio, and, consequently, that there is a decrease in sales to Japan and third countries. Put differently, small countries tend to be export platforms selling to third countries.

On the other hand, the GDP difference was negative with local procurement but positive with that from Japan. It showed a negative sign for third countries but was not significant. These observations mean that the larger the economy of the ASEAN host country the more procurement is carried out locally and, consequently, the less procurement there is from Japan.

4.2.4. Trade costs

The third term, trade costs in the host country was positive for those with a local sales ratio but negative for those with a sales ratio to Japan or to third countries. The same signs were obtained for procurement. On the other hand, trade costs in the destination country were negative with sales to third countries. The estimation was significant, except for electrical appliances & electronics.

These observations indicate that a high tariff policy in a host country works to encourage sales in the host country and procurement but discourages sale to third countries and procurement from them. In other words, a high tariff policy is effective in protecting and fostering domestic industries but is an impediment if a host country is to act as an export platform.

4.2.5. Investment costs in the host country

Investment costs in the host country was negative with local sales but positive

with sales to Japan[6]. These results mean that the reduction in investment costs in the host country, that is, the set-up costs, contributes to an increase in sales in the country and lessens dependence on Japan.

4.2.6. Operation year

The year a firm started its operations showed a positive sign with local sales and sales to third countries but was negative with sales to Japan, but these results were not robust since the figures for affiliates that started after 1992 were not significant.

4.2.7. Geographical distance

Geographical distance was employed to explain the behavior of sales to third countries and procurement from them. As was to be expected, geographical distance was negative with third countries. This observation means that Japanese affiliates tend to sell to neighboring countries and procure from them. However, the estimated results for automobiles were not significant although the sign was right. This result does not contradict the case study on automobiles in the previous section in which the automobile sector procures most of its parts and components from domestic suppliers, except for several key parts based on intra-firm procurement.

5. SUMMARY AND IMPLICATIONS

A major feature of international trade is the rapid expansion of intermediate trade, which inputs materials, parts and components for manufacturing. Behind the expansion of international intermediate trade, production networks have extended across countries, particularly in the Asia-Pacific region. To investigate international production networks, two micro-level approaches were employed. One consists of the case studies to see the source of procurement by assemblers operating in ASEAN. The other is an econometric analysis of the determinants of sales and procurement by destination and origin. For this purpose, JETRO's firm surveys of Japanese affiliates operating in ASEAN in 2006, 2007 and 2008 were used. These two approaches discovered the following facts and implications for policy.

First, hard disc drive (HDD) assemblers procured from more overseas suppliers than from local suppliers in terms of the number of components procured. On the other hand, the automobile industry procured most of its parts and components from suppliers

[6] The estimation was not robust for cases with sales to third countries.

in the host country but obtained key parts from their parent and overseas. Put differently, international production networks have developed more in the HDD industry than in the automobile industry. This is because the transportation costs associated with HDD industry are lower than those of the automobile industry. This suggests that reduced transportation costs, which can be realized by unilateral tariff reduction, FTAs, and multilateral trade negotiation, may encourage production fragmentation and thereby develop international production networks and increase intermediate input trade. On the other hand, there are risks that a halt in operations by a supplier will hurt global production through the disruption of supply chains. Indeed, due to the Great East Japan Earthquake on March 11, 2011, several factories were closed and supply chains collapsed. Automobile manufacturers in Japan had made efforts to source parts from multiple suppliers but they found that many contractors relied on the same quake-hit makers for materials and electronics components.

Second, empirical analysis tells us that Japanese multinationals allocate labor intensive production processes in ASEAN where unskilled labor is relatively abundant, leaving capital intensive headquarters functions in Japan where skilled labor is abundant. However, it is not confirmed that they allocate production processes vertically in ASEAN according to country specific advantages in human resources.

Third, most overseas suppliers tend to be located in countries neighboring the countries of the assemblers, e.g. a factory in Thailand mainly procured from Indonesia, Malaysia, the Philippines, and Singapore. This indicates that international production networks have concentrated in a small region. There are two reasons for this. One is that the assembler can reduce transportation costs. The other is that the suppliers' engineers can easily travel to solve problems when they happen. Indeed, it was empirically confirmed that geographic distance was negatively related to export destination and import procurement. This geographical proximity is necessary for solving problems as quickly as possible after they occur.

Fourth, international production networks have been supported by intelligent logistic systems. The "just in time" warehouse system, which provides services to temporarily store intermediate goods from both international and domestic suppliers in the warehouse and deliver them to the customer, has developed in the electronics industry where a large number of parts and components are procured from overseas. This fact has two important implications. One is that liberalization in services is essential because logistic services facilitate international production networks. The other is that trade facilitation measures are very important for international production networks.

Lastly, a high tariff policy in the host country may protect and foster local

suppliers through the expansion of procurement from domestic suppliers, either indigenous or foreign, but it discourages a country from being an export platform. The larger an economy is the more it procures from domestic suppliers in the country. Thus a high tariff policy may tend to be selected by larger economies. However, considering that Asia has achieved export-led growth, a low tariff policy is necessary for further development through export platforms in the region.

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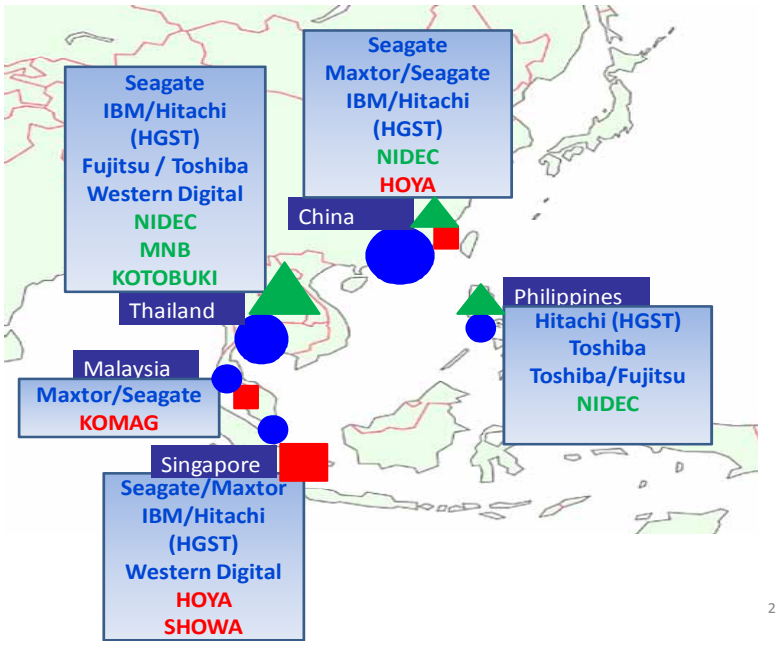
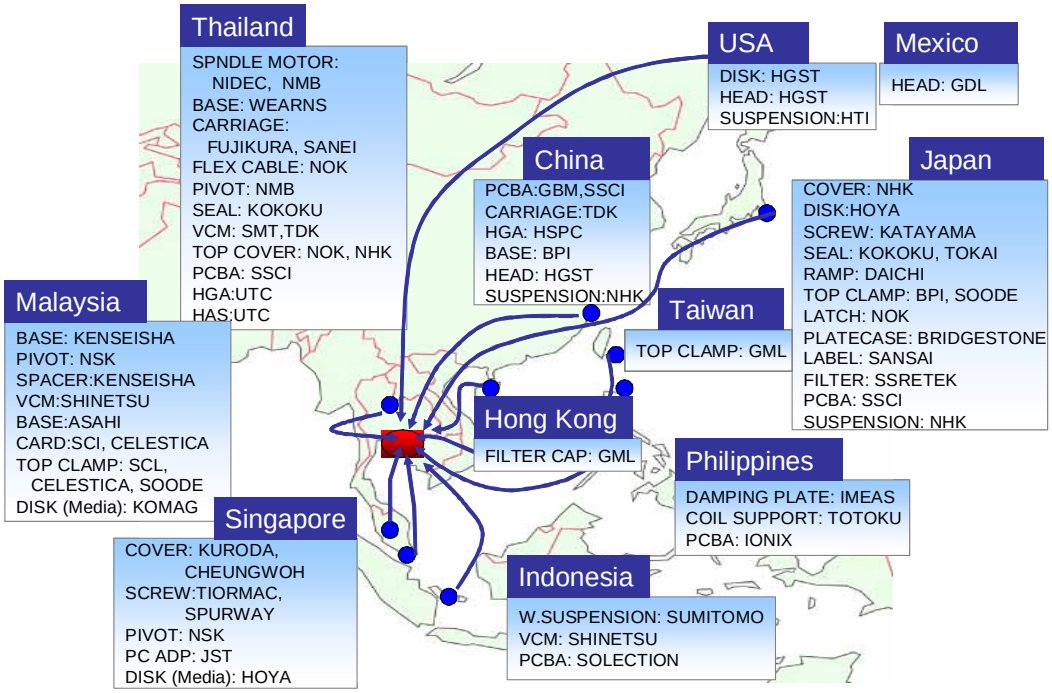
Diagram 1: HDD Assemblers in East Asia



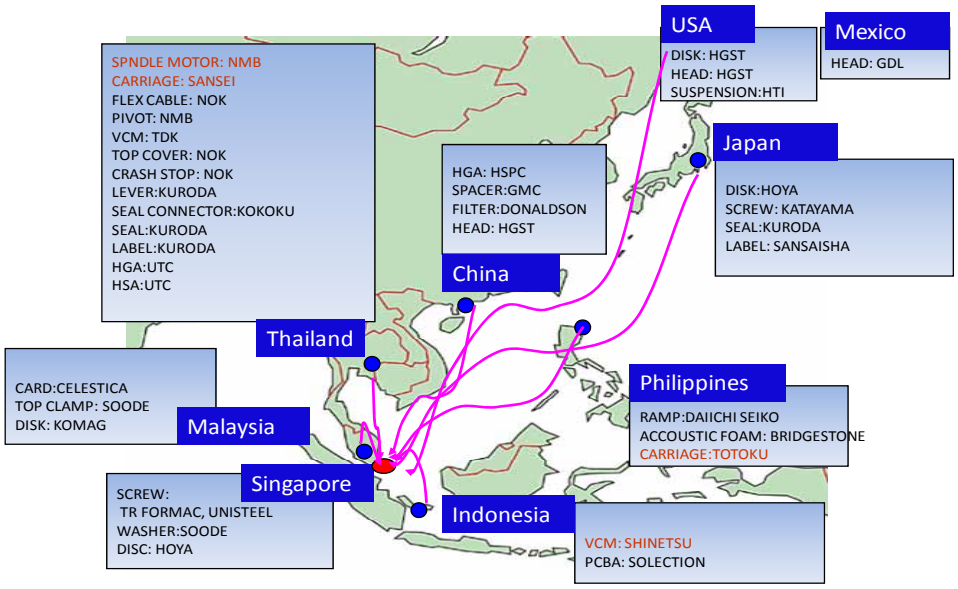
Source: Author

Diagram 2: International Procurement: An HDD Assembler in Thailand in 2005



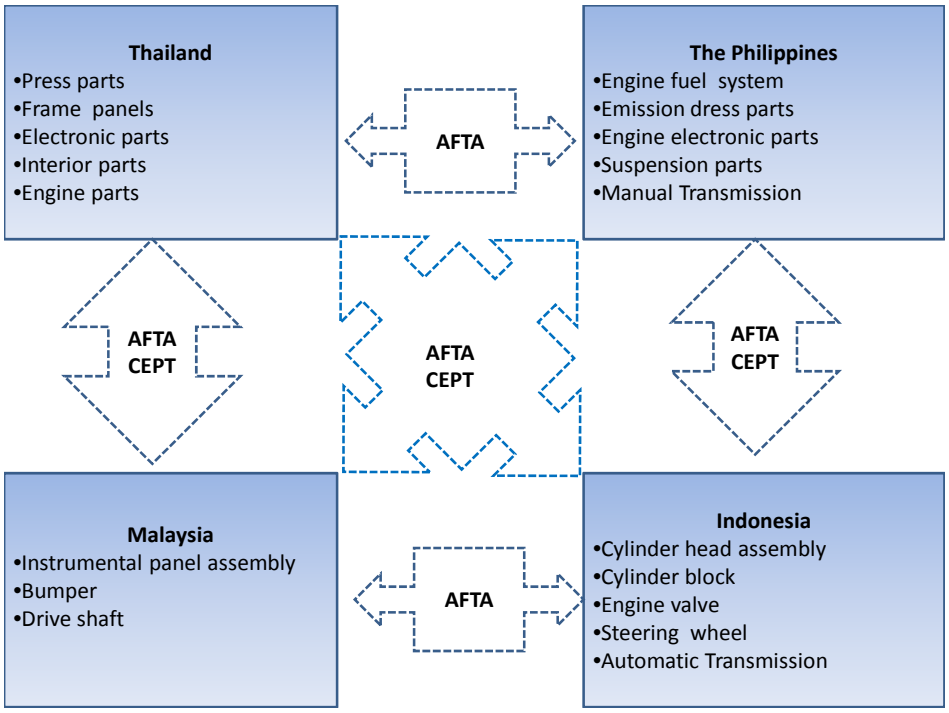
Source: Hiratsuka, Daisuke (2006). "Vertical Intra-Regional Production Networks in East Asia: Case of the Hard Disk Drive Industry in East Asia," in Hiratsuka, D. ed., *East Asia's De Facto Economic Integration*, Chapter 6, London: Palgrave Macmillan.

Diagram 3: International Procurement: An HDD Server Assembling in Singapore



Source: Compiled by the author, based on an interview at Hitachi Global Storage Technology (Thailand), August 2005.

Diagram 4: Complementary Parts Supply within ASEAN in Automobile Industry



Source: Compiled by the author.

Table 1 FDI Types of Japanese Affiliates in ASEAN

	Horizontal FDI		Vertical FDI		Export-platform FDI		Total	
	a number of firms	share	a number of firms	share	a number of firms	share	a number of firms	share
Indonesia	193	60%	65	20%	65	20%	324	100%
Malaysia	161	43%	74	20%	139	37%	375	100%
Philippines	103	26%	139	35%	152	39%	395	100%
Singapore	57	30%	12	6%	119	63%	189	100%
Thailand	431	65%	109	16%	126	19%	667	100%
Vietnam	58	33%	72	41%	45	26%	176	100%
Total	1,003	47%	471	22%	646	30%	2,121	100%

Note: Horizontal FDI is for a firm whose sales are mostly in the domestic market of the host country. Vertical FDI is for a firm whose sales are mostly to Japan. Export-platform FDI is for a firm whose sales are mostly to third countries.

Source: Compiled by the author based on the JETRO Survey on the affiliates in ASEAN.

Table 2 Occupational Group and Skilled Labor (% of Total Employment)

	Occupation Group 1	Occupation Group 2	Occupation Group 3	Skilled Labor Ratio
Viet Nam	1%	3%	3%	7%
China	2%	6%	0%	8%
Indonesia	4%	0%	5%	9%
Thailand	7%	4%	4%	15%
Philippines	11%	4%	3%	18%
ASEAN	7%	5%	7%	19%
Republic of Korea	3%	8%	10%	21%
Malaysia	8%	5%	13%	26%
Taiwan	4%	8%	18%	30%
Hong kong	9%	7%	18%	34%
United States	15%	20%	0%	35%
Japan	14%	3%	20%	37%
Singapore	14%	13%	18%	45%

Note: International Standard Classification of Occupations (ISCO-88)) classifies workers into eight groups. Occupational Group 1(Legislators, senior officials and managers), Group 2 (Professionals), and Group 3 (Technicians and associate professionals) can be regarded as skilled labor.

Source: INTERNATIONAL LABOUR ORGANIZATION Geneva.

Table 3 Estimated Results: Local Sales Ratio

Share of sales in the host country	All firms	Machinery	Automobiles	Electrical appliances & electronics	Established before 1990	Established after 1991
	(1)	(2)	(3)	(4)	(5)	(6)
Skill differecne	4.910 ***	7.814 ***	1.035	5.389 *	4.957 ***	3.542 **
	(4.060)	(4.010)	(0.380)	(1.950)	(2.880)	(2.020)
GDP difference squared	-0.192 ***	-0.199 ***	-0.192 ***	-0.190 ***	-0.204 ***	-0.154 ***
	(-7.500)	(-5.000)	(-3.570)	(-2.940)	(-6.580)	(-3.310)
Trade cost host	0.116 ***	0.148 ***	0.347 ***	0.123 ***	0.147 ***	0.092 ***
	(6.640)	(5.200)	(5.600)	(2.640)	(5.360)	(3.530)
Investment cost host	-0.710 ***	-0.817 ***	-0.310 *	-0.945 ***	-0.797 ***	-0.500 ***
	(-9.030)	(-6.720)	(-1.890)	(-4.430)	(-7.410)	(-3.980)
Operation year	0.155 ***	0.135	0.351 ***	0.127	0.119	1.085 ***
	(2.65)	(1.33)	(2.79)	(0.72)	(1.22)	(5.95)
Constant	5.209 ***	4.815 ***	2.632 *	5.318 ***	5.540 ***	1.521
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted R-sq	0.1251	0.1754	0.2997	0.1157	0.1585	0.1145
No. of observations	1,943	828	320	394	1,141	802

Note: Figures in the first row of parentheses below the coefficients are t-statistics, and ***, **, and * show 1%, 5%, and 10% significance, respectively.

Table 4 Estimated Results: Sales Ratio to Japan

Share of sales to Japan	All firms	Machinery	Automobiles	Electrical appliances & electronics	Established before 1990	Established after 1991
	(1)	(2)	(3)	(4)	(5)	(6)
Skill differecne	-0.105	-0.167	0.654 **	0.049	-0.180	0.080
	(-0.470)	(-0.560)	(2.500)	(0.110)	(-0.520)	(0.260)
GDP difference squared	0.027 ***	0.029 ***	0.027 ***	0.031 ***	0.030 ***	0.022 **
	(5.520)	(4.340)	(3.150)	(2.880)	(4.860)	(2.480)
Trade cost host	-0.005	-0.008 *	-0.024 ***	-0.008	-0.006	-0.002
	(-1.620)	(-1.900)	(-3.510)	(-1.110)	(-1.460)	(-0.520)
Investment cost host	0.105 ***	0.097 ***	0.046 **	0.127 ***	0.122 ***	0.081 ***
	(7.160)	(4.980)	(2.030)	(3.640)	(6.140)	(3.450)
Operation year	-0.002 **	-0.001	-0.003 **	0.002	-0.002	-0.004 ***
	(-2.15)	(-1.05)	(-2.53)	(0.82)	(-0.57)	(-2.61)
Constant	-0.344 ***	-0.336 ***	-0.194	-0.500 ***	-0.421 ***	-0.191
	(-4.770)	(-3.500)	(-1.310)	(-3.260)	(-4.590)	(-1.520)
Adjusted R-sq	0.0615	0.0721	0.0923	0.083	0.0657	0.0592
No. of observations	2,037	867	342	406	1,201	836

Table 5 Estimated Results: Sales Ratio to Third Countries

Share of sales to third countries	All firms	Machinery	Automobile	Electrical appliances & electronics	Established before 1990	Establshed after 1991
	(1)	(2)	(3)	(4)	(5)	(6)
Skill differcne	0.085 ***	0.045	0.013	0.011	0.057 **	0.121 ***
	(4.030)	(1.170)	(0.320)	(0.180)	(2.120)	(3.810)
GDP difference squared	0.002 ***	0.004 ***	0.004 ***	0.005 ***	0.002 ***	0.002 **
	(4.990)	(5.490)	(3.460)	(3.820)	(3.530)	(2.460)
Trade cost host	-0.003 ***	-0.004 ***	-0.010 **	-0.001	-0.005 ***	-0.002 **
	(-4.430)	(-3.340)	(-2.570)	(-0.630)	(-3.670)	(-2.010)
Distance	-0.006 *	-0.010 *	-0.005	-0.011	-0.005	0.000
	(-1.720)	(-1.810)	(-0.580)	(-1.080)	(-1.250)	(-0.050)
Investment cost host	-0.001	-0.003	0.002	-0.002	-0.002	-0.003
	(-0.51)	(-0.71)	(0.26)	(-0.33)	(-0.65)	(-0.74)
Operation year	0.003 *	0.004	-0.003	0.004	0.007 **	-0.014 **
	(1.670)	(0.890)	(-0.890)	(0.400)	(2.150)	(-2.450)
Constant	0.068 ***	0.120 ***	0.105 **	0.115	0.079 ***	0.071 *
	(3.030)	(3.000)	(2.360)	(1.580)	(3.000)	(1.700)
Adjusted R-sq	0.1008	0.1127	0.0825	0.1354	0.0984	0.104
No. of observations	6,105	2,601	1026	1218	3597	2508

Note: Same as Table 3

Table 6 Estimated Results: Procurement Ratio from Local Suppliers

Procurement from local market	All firms	Machinery	Automobiles	Electrical appliances & electronics	Established before 1990	Established after 1991
	(1)	(2)	(3)	(4)	(5)	(6)
Skill differecne	2.907 ***	1.632	0.700	2.161	3.750 **	2.187
	(2.760)	(1.090)	(0.220)	(1.100)	(2.330)	(1.560)
GDP difference squared	-2.985 ***	-2.320 **	-3.579 **	-0.984	-2.252 **	-3.909 ***
	(-3.810)	(-2.160)	(-2.130)	(-0.590)	(-2.260)	(-2.770)
Trade cost host	0.157 ***	0.165 ***	0.142 **	0.154 ***	0.181 ***	0.143 ***
	(8.870)	(6.170)	(2.060)	(4.220)	(5.520)	(5.820)
Investment cost host	-0.428 ***	-0.341 ***	-0.416 **	-0.376 **	-0.410 ***	-0.412 ***
	(-5.840)	(-3.290)	(-2.070)	(-2.480)	(-3.750)	(-3.750)
Operation year	0.132 **	0.108	0.007	0.225 *	0.126	-0.134
	(2.590)	(1.510)	(0.070)	(1.800)	(1.540)	(-0.910)
Constant	3.172 ***	2.997 ***	4.166 ***	2.471 ***	2.583 ***	4.400 ***
	(8.620)	(5.760)	(3.530)	(3.300)	(4.420)	(6.350)
Adjusted R-sq	0.0888	0.0898	0.0898	0.0816	0.0851	0.094
No. of observations	1,880	796	313	374	1095	785

Note: Same as Table 3

Table 7 Estimated Results: Procurement Ratio from Japan

Procurement from Japan	All firms	Machinery	Automobile	Electrical appliances & electronics	Established before 1990	Established after 1991
	(1)	(2)	(3)	(4)	(5)	(6)
Skill differcne	1.663	-0.463	1.399	0.322	2.112	1.551
	(1.520)	(-0.340)	(0.590)	(0.170)	(1.270)	(1.060)
GDP difference squared	4.692 ***	3.093 ***	3.308 **	3.915 **	4.989 ***	3.652 ***
	(6.390)	(3.150)	(2.040)	(2.440)	(5.350)	(2.750)
Trade cost host	-0.046 **	-0.020	-0.044	0.002	-0.067 **	-0.047 *
	(-2.590)	(-0.810)	(-0.640)	(0.050)	(-2.250)	(-1.930)
Investment cost host	0.216 ***	0.146	0.169	0.093	0.160	0.223 *
	(2.830)	(1.430)	(0.910)	(0.600)	(1.440)	(1.950)
Operation year	-0.205 ***	-0.202 ***	-0.149	-0.175	-0.138 *	-0.501 ***
	(-3.820)	(-2.710)	(-1.510)	(-1.270)	(-1.670)	(-3.040)
Constant	1.735 ***	2.794 ***	2.343 *	2.454 ***	1.818 ***	2.888 ***
	(4.900)	(5.910)	(1.930)	(3.250)	(3.390)	(3.930)
Adjusted R-sq	0.0498	0.0382	0.0382	0.0452	0.0512	0.0327
No. of observations	1,902	807	321	376	1111	791

Note: Same as Table 3

Table 8 Estimated Results: Procurement Ratio from Third Countries

Procurement from third countries	All firms	Machinery	Automobiles	Electrical appliances & electronics	Established before 1990	Established after 1991
	(1)	(2)	(3)	(4)	(5)	(6)
Skill differecne	2.473	6.911 **	1.922	8.245	-3.659	7.941 ***
	(1.220)	(2.060)	(0.390)	(1.500)	(-1.150)	(3.030)
GDP difference squared	-1.542	-1.171	-2.099	-1.711	-4.546 **	2.579
	(-0.950)	(-0.490)	(-0.540)	(-0.400)	(-2.150)	(0.950)
Trade cost host	-0.140 **	-0.273 ***	-0.440 *	-0.211	-0.418 ***	0.080
	(-2.130)	(-2.750)	(-1.710)	(-1.210)	(-3.260)	(0.840)
Distance	-1.289 ***	-1.559 ***	-0.615	-2.249 ***	-0.680 *	-1.920 ***
	(-5.100)	(-4.320)	(-1.170)	(-3.450)	(-1.960)	(-4.890)
Investment cost host	0.051	0.177	0.260	-0.040	0.016	-0.131
	(0.260)	(0.590)	(0.430)	(-0.080)	(0.050)	(-0.450)
Operation year	0.501 **	0.868 ***	0.619 *	0.741	0.138	1.017
	(2.440)	(3.010)	(1.750)	(1.250)	(0.500)	(1.410)
Constant	13.277 ***	14.461 ***	8.008 *	21.764 ***	12.528 ***	14.612 ***
	(7.290)	(5.410)	(1.860)	(4.610)	(4.960)	(4.170)
Adjusted R-sq	0.0161	0.0313	0.0313	0.0428	0.0187	0.0187
No. of observations	5,640	2,388	939	1122	3285	2355

Note: Same as Table 3